POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

Contents

Sentinels of the Power Lines 204
With the Editors 205
Registration of Professional Engineers. When Father Was Air Minded.
More Power to Cahokia. By E. H. Tenney and G. V. Williamson 206
Small Steam Turbines, Care and Operation. By H. W. Newbergh 210
Mercury in Small Boilers 213
Superposition. By C. W. E. Clarke 215
Diesels for Automatic Standby. By Harvey R. Artman 216
Jacket Piping Change Aids Cleaning. By Elton Starrett 219
New California Pipe Line 219
Electron Tubes—Principles and Applications. By A. W. Kramer 220
Self-Regulated Compound Rectifiers. By W. Melvin Goodhue 224
Research in Progress 225
A New Type of Circuit Breaker. By Frank A. Eastam 226
What a Steam Trap Can Do 228
Grand Rapids Stamping Div. of General Motors Corp. 229
Principles Underlying Furnace and Heat Trap Design. By Pulverizer Pete 230
Pulverized Fuel Presents Operating Problems. By Mark Bell 232
Refrigeration System Control. By W. R. Kitzmiller 233
Humidity in Control 235
Steel Mill Explosion 236
Cotton Hose for Humidity Control 236
Drying Flooded Electrical Apparatus 237
Industrial Minerals in 1936 239
Power Production with Iowa Coal. By John M. Drabelle 240
Modified Chromium Steels 242
Flow Through Labyrinth Glands. By Dr. C. Keller 243
Readers' Conference 246
New Equipment 252
News from the Field 257
For the Engineer's Library 259
Power Plant Construction News 262

Contents of back issues of Power Plant Engineering will be found in Industrial Arts Index on file in Public Libraries.

APRIL
1937

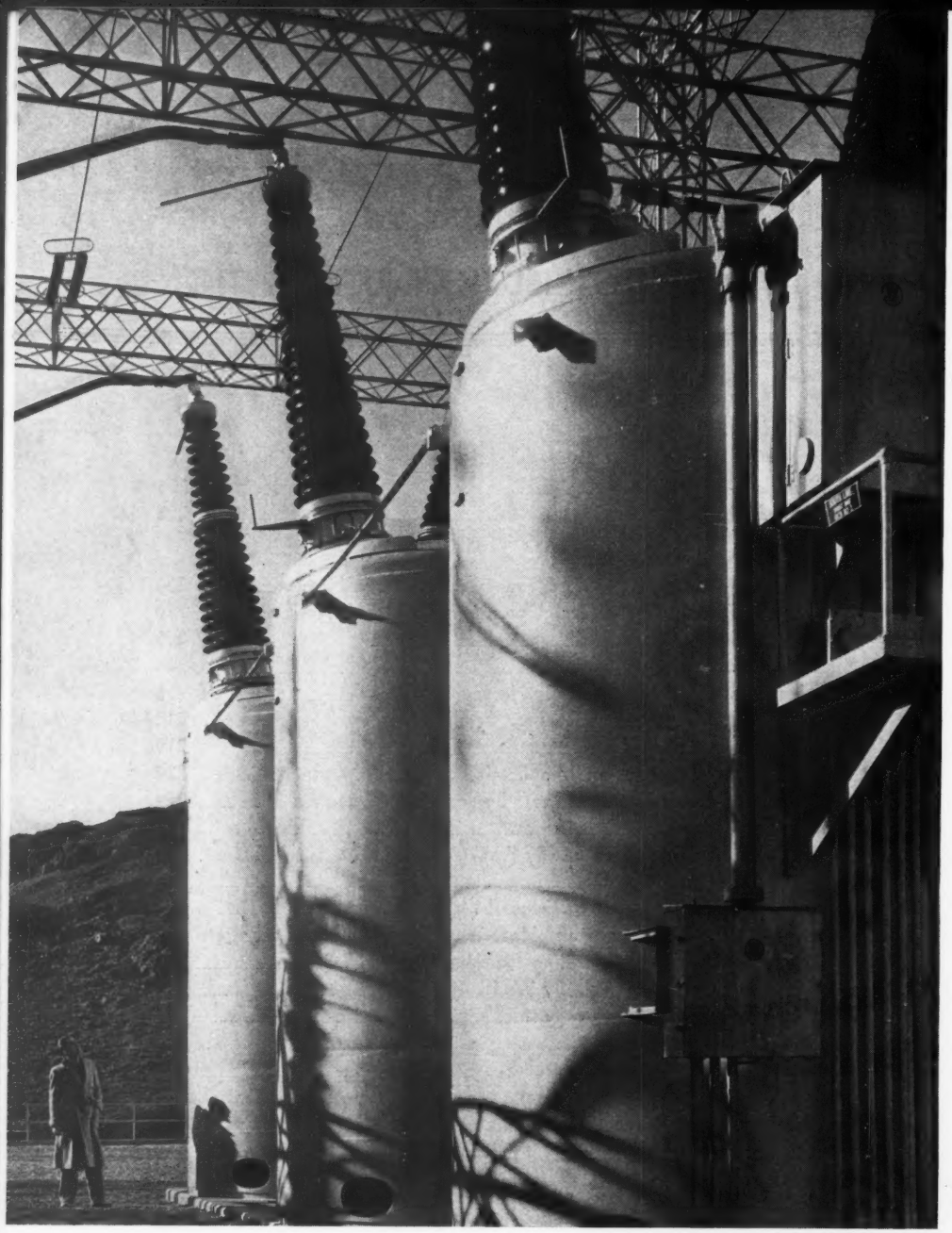
Vol. XLI., No. 4

Published on the first of each month, copyright 1937 by the
Technical Publishing Co., 53 W. Jackson Blvd., Chicago.
New York Office, 171 Madison Ave.

EDITORIAL STAFF: ARTHUR L. RICE, Editor. R. E. TURNER, Managing Editor.
A. W. KRAMER, RICHARD H. MORRIS, Associate Editors.

Subscription price. U. S. A. $2.00 a year; other countries, $3.50 a year. Single copy current issue, 25c; other countries, 35c. January issue, U. S. A., 50c; other countries, 60c. Back issues, single copy, U. S. A., 40c; other countries, 50c. January issue, U. S. A., 75c; other countries, 85c.

Member, Associated Business Papers, Audit Bureau of Circulations.
Circulation of this issue, 20,400



287,000 V. Circuit Breakers on the Boulder Dam—Los Angeles Transmission Line. Photo, Bureau of Reclamation.

Sentinels of the Power Lines

CAUGHT in the slanting rays of the afternoon sun these giant circuit breakers loom up impressively—silent sentinels guarding the flow of millions of kilowatt hours of electrical energy over the highest voltage transmission line in the world. For these are the breakers at Boulder Dam, the 287,000 volt units carrying energy for the City of Los Angeles, 250 miles away. Outwardly, they give little indication of the huge forces under their control; their calm, peaceful exteriors give no clue to the pent up forces of man-made lightning which it is their function to keep under control at all times. Under the control of sensitive relays it is their duty to maintain watch at all times day in, day out, year in, year out, to act in the case of any serious abnormality in the operation of this famous line. Strangely enough, the engineers who installed them hope they will not be called upon to act too often, even though they know these units can interrupt the flow in 3 cycles, a twentieth of a second. For a circuit breaker like any other protective device is at its best when it does not operate—when it is ready to operate.

WITH THE EDITORS

Registration of Professional Engineers

FROM TIME to time the question of licensing or registering engineers has come up for consideration in the legislatures of various states. The licensing of engineers in charge of steam power plants has been the law in a number of states for many years, and many cities have adopted ordinances where state laws are not in effect. Although there are groups of interested individuals that have been successful in blocking legislation of this nature in many states and cities, it is noteworthy that these laws have been effective in raising the quality of engineers in charge of plants and likewise reducing the prevalence of accidents attributable to ignorance on the part of operating engineers, even during the period of rapidly increasing boiler pressures and the development of intricate control equipment. On the basis of the results secured, few can question the merits of laws that have been passed and carefully enforced.

Another form of engineer's license has been passed by thirty-five states of the Union and is now up for consideration by the legislature of the State of Illinois. It is a bill known as "The Illinois Professional Engineering Act" which requires all persons engaged in any professional service, such as consultation, investigation, evaluation, planning, design, or responsible supervision of the construction, in connection with any public or privately owned public utilities, structures, buildings, machines, equipment, processes, works or projects, wherein the public welfare, or the safe guarding of life, public health or property is concerned or involved, when such professional service requires the application of engineering principles and data, to be registered in the state as a *professional* engineer.

One section of the bill defines the term professional engineer as a person who, by reason of his knowledge of mathematics, the physical sciences, and the principles of engineering, acquired by professional education and practical experience, is qualified to engage in engineering practice as outlined in the previous paragraph. Penalties are, of course, provided for practicing *professional* engineering without being registered as such.

As written, this bill follows substantially the "Model Registration Law" as adopted by most states in recent years and will affect the means of livelihood of many engineers now practicing in the State of Illinois. Although the requirements for registration are no higher than industry should expect of those employed for such service, the law may place a temporary hardship on some who have learned their specific job of design or supervision through the school of experience. With this law in effect, employers of *professional* engineers may be required to rearrange the duties of their various employes now doing engineering work.

Such a law properly enforced should insure to the public safer structures and to professional engineers a recognition for which they have long striven, comparable in a limited way to doctors, lawyers, architects, structural engineers and certified public accountants.

This bill has the backing of an organization of engineers known as the Illinois Committee for Registration of Engineers and should have the consideration of all resident engineers in any way affected by its provisions. Unquestionably members of the Legislature would welcome either individual or group opinions regarding the passage of this proposed law.

When Father Was Air Minded

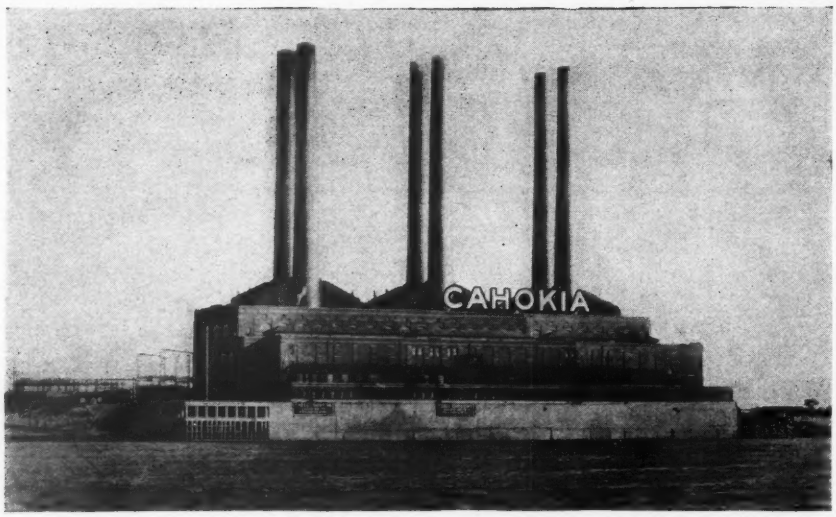
NEWS TRAVELS far and news travels fast but is soon overtaken by progress. "A plant is to be erected at Niagara, N. Y., by the Niagara Power Co. There will be a central station for the generation of 5000 hp. by compressed air, and another for the generation of 5000 hp. by electricity, with the possible extension of either one of these to the amount of 100,000 hp. This power will be distributed . . . . . within a 25 mi. radius.

"Deductions by Prof. Unwin prove that power can be transmitted this distance without excessive loss of pressure, for he computes that air compressed to an initial pressure of 132 lb. per sq. in. can be carried a distance of 20 mi. in a 30-in. main with a loss of pressure of only 12 per cent, and that from 40 to 50 per cent of the compressing power can be recovered in the motors if the air is used cold, and from 59 to 73 per cent if the air is reheated."

News that thrilled father back in 1903 today causes son to roar with laughter and even brings a grin or two and a chuckle from father himself. Transmission of power by steam, water, air and electricity were about on a par at that time and were all in commercial use with more or less success. The Hydraulic Power Co. of London, the Paris Compressed Air Co. and others were making history. Some may even remember that New York had a cross-town carline operated by high pressure air from bottles.

Hydraulic and pneumatic transmission of power has never completely passed from the picture and is today widely used for control purposes. The larger commercial ventures passed from the picture not so much due to fundamental limitations as to the fact that electricity offered a more flexible and efficient system adaptable to large units.

Today electricity is solidly in the saddle yet it is not beyond the realm of possibility that by 1975 engineers will look upon our present 100,000-kw. power units with the same amusement that we now look back on the compressed air era of 1903.



MORE

For almost a decade Cahokia, standing on the banks of the Mississippi River, opposite St. Louis, has done more than its share of pioneering and played a leading role in the industry

EARLY IN THE FALL of 1935, it appeared that the Tri-State system of the Union Electric Light & Power Co. serving St. Louis and certain adjacent territory in Missouri, Illinois, and Iowa was experiencing a load growth which if continued would necessitate additional generating capacity early in 1938. An extended study of all phases of the problem indicated the capacity could best be obtained by installing a 75,000 kw. turbine with necessary boilers in the space remaining at Cahokia, where five other turbines and nineteen boilers had been installed between 1923[1] and 1929.[2]

To a large measure system load characteristics have determined the engineering features of the new equipment. The Tri-State system is served by three major plants consisting of the Cahokia steam plant and two hydro plants, one at Keokuk, Iowa, on the Mississippi, and the other at Bagnell on the Lake of the Ozarks in Central Missouri. Keokuk is a run of the river plant, and the "Osage" Plant at Bagnell is backed by a storage pond with at least fifty million kilowatt hours draw-down. When water is plentiful the hydro plants carry a base load with Cahokia carrying a minimum night load and the day and evening peaks. With minimum water the hydro plants "cut-off" the peaks, leaving a base load for Cahokia and variable loads for three minor steam plants.

System Load Influence

The system capacity being dependent upon the continuous rating of the steam plants, the new equipment to be installed at Cahokia is adding to the effective firm capacity of the system only in the amount it can carry twenty-four hours a day, five days a week for the period of sixty week drought. At the same time it must be capable of carrying sustained minimum loads equivalent to about 20 per cent of rated capacity when water is plentiful. At such times the system reserve must also be carried on steam which means that the steam plant, even when carrying minimum load, must be capable of picking up instantly three and a half times that load. The additional capacity to be installed at Cahokia therefore must be capable of carrying (1) sustained full load, (2) low minimum loads, and (3) of meeting wide swings in load.

The turbo-generator is to be a 75,000 kw. 1800 r.p.m. unit utilizing steam at 315 lb. per sq. in. pressure and 725 deg. F. The size unit was limited by two factors: (1) the space available for boilers, and (2) the size of units already installed, since the system reserve is usually equal to the largest unit. The largest single unit already on the system is a 75,000 kw. steam turbine installed in 1929.[2] The space available for boilers, turbine and auxiliaries permitted the installation of steaming and generating equipment not to exceed this amount.

Heat Balance

Pressure and temperature were established by those already existing in the station. An economic study indicated that with low priced coal the gain in economy at higher pressures could not offset the added expense of extra supervision, duplicate service, additional standby and higher fixed charges on a separate pressure system. Superposition is not a suitable plan because present low pressure turbines have little need for additional steam and long periods of operation as standby for hydro does not lend itself to the com-

Table I. Thermal performance of the new section under different operating conditions

	Full Load	Average Load	Standby Load
Kw. Output	75,000	62,000	15,000
Pres. at throttle, lb. ga.	315	315	315
Temp. at throttle, ° F.	725	715	700
Throttle Flow, lb./hr.	748,000	600,000	164,000
Feed Temperature	324	298	197
Auxiliary Power	4.0%	4.1%	123,456 4.6%
B.t.u./kw-hr. Net Plant	13,580	13,320	16,070
Capacity use factor	31%,		(20 yr. av.)
B.t.u./lb. of coal	10,690	10,690	10,690
Boiler Efficiency, %	83.9	84.1	84.5

[1]For a description of the original section of Cahokia see Power Plant Engineering, p. 365, April 1, 1924.

[2]In 1928 one of the original 35,000 kw. units was replaced by a 75,000 kw. unit. See Power Plant Engineering, p. 947, Sept. 1; p. 730, July 1; p. 790, July 15, 1929.

POWER TO CAHOKIA

Load increases in St. Louis territory lead to plans for a 75,000 kw., 315 lb., 725 deg. F. Unit No. 6 and five new boilers to be completed in November.

By

E. H. Tenney
Chief Engineer of Power Plants

G. V. Williamson
Assistant to Chief Engineer of Power Plants

Union Electric Light & Power Co., St. Louis, Mo.

plications of a reheat cycle. The economics of steam pressure is also effected by the estimated annual use factor of the new installation, which has been estimated at 31 per cent, over the 20 yr. period of its amortization.

The turbine to be installed will be a 16-stg. single cylinder unit, operating at 1800 r.p.m., with double winding and 80 per cent power factor. A cost analysis indicated that additional reactance could be added to the system by installing a generator of this comparatively low power factor at less expense than by the addition of a synchronous condenser. The turbine foundation is a combined concrete and steel structure, the lower half being of concrete, and the upper half of fabricated steel. This design has proven to give the best combination of stability, accessibility to the lower half of the turbine and available space for piping and mounting of accessories at the main unit. The concrete portion is reinforced with 1-in. bars, with ¾-in. aggregate. The steel portion is designed on the basis of a maximum 0.02-in. deflection.

Because a comparatively large portion of the turbine's operation will be at high loadings during dry summers when circulating water temperatures are high, the new turbines and boilers are designed to carry full load of 75,000 kw. continuously at 2.5 in. Hg. back pressure. The generator air cooler is proportioned to operate with 97 deg. F. condensate and the condenser is sized for 65,000 sq. ft. surface and 76,000 g.p.m. of circulating water to produce the 2.5 in. Hg. back pressure with 86 deg. F. water. The condenser is of two pass design, with two banks of tubes sloped at 10 deg. for drainage. The tubes are rolled and belled at the inlet end and packed with metallic packing at the other.

Three Stages of Extraction

The regenerative cycle, Fig. 1, is based on three stages of extraction, the high and low stages being used for closed heaters, and the middle stage for both deaerator and evaporator. The deaerator is designed to give deaeration for an outlet capacity nearly 50 per cent greater than turbine throttle flow in order to care for conditions when the boilers it serves are generating more steam than is used by the new turbine alone. The deaerator is of the tray type using welded construction designed for minimum space, resulting in a rectangular unit 6 by 15 by 15 ft.

A heat exchanger is provided in the condensate system immediately after the condenser hotwell pump to reduce condensate temperature sufficiently low to take care of the generator air cooling during the short periods when river water temperature exceeds 83 deg. F. The evaporator is of the bent tube type, two effect, and designed for 30,000 lb. per hr. of distillate at full load on

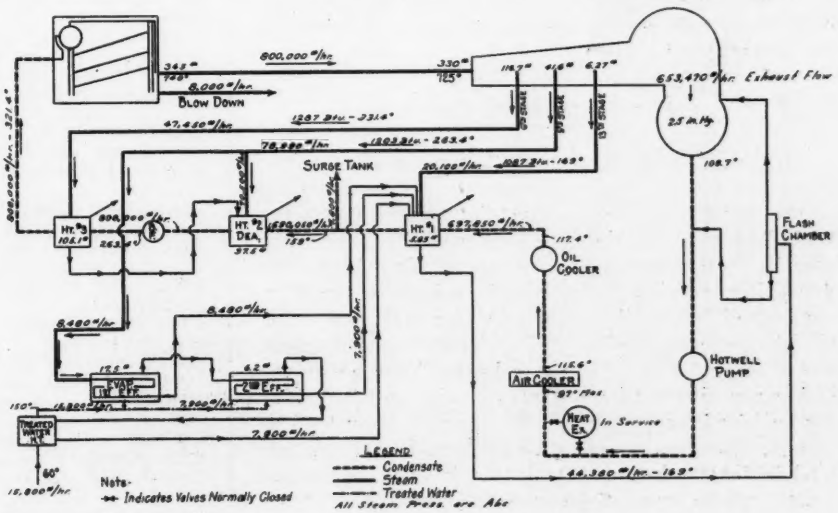


Fig. 1. Heat Balance of the new unit for full load of 75,023 kw.

Fig. 2. The Tri-State System is served by 3 major plants, Cahokia, Keokuk and Osage

the turbine. A conventional surge tank arrangement is used, the upper elevation being sufficient to deliver water into the deaerator against top extraction steam pressure in that unit.

Boiler feed pumps have a capacity of 1800 gal. per min. each, for one motor and one turbine driven unit. This will be the second boiler feed pump in the station to be steam driven, the two such pumps together being able to carry 175 per cent rating on all boilers at once, or 50 per cent of top station output.

A brief summary of expected thermal performance of the new unit and its related equipment is given in the accompanying table.

Boiler and Pulverizing Equipment

Reflected in the new boiler-furnace design, is the nature of the Tri-State hydro-steam system resulting in prolonged periods of steam plant operation at top load during water shortage, followed by periods of plentiful water supply and low steam plant load. The five boilers serving the new turbine have a top 2 hr. capacity of 260,000 lb. per hr. of steam each, and a continuous capacity of 190,000 lb. Thus, with a turbine water rate of about 10 lb. per kw-hr., four boiler out of five can give continuous full capacity on the turbine for an indefinite period. When the unit is on load as standby three boilers can pick up from 15,000 to a full load of 75,000 kw. and maintain it until additional boilers can be brought onto the line from cold.

Boiler steaming output of 260,000 lb. per hr. represents a 20 per cent increase in capacity over the boilers last installed, but both old and new boilers occupy equal space in the boiler room. This increase in capacity is made possible by (1) improved furnace wall construction that lowers furnace temperatures below the slagging point at a heat liberation of 26,000 B.t.u. per cu. ft. per hour, and (2) a horizontal mixing type of circular burner that gives a rapid rate of ignition and complete combustion with low excess air.

Furnace bottom, Fig. 3, is of the dry type, chosen in preference to a wet bottom design because of the

Principal Equipment for Unit No. 6 Cahokia Power Plant

TURBINE ROOM

TURBINE—General Electric Co. 75,000 kw., 1800 r.p.m., 315 lb., ga., 725 deg. F. steam, 16 stage, 3 stg. of extraction, condensing turbine giving full load at 2.5 in. Hg. back pressure, driving a 3 phase, 60 cycle, 13,800 v., 80 per cent power factor, double winding generator, with direct connected exciter.
AUXILIARY EXCITER—Westinghouse Elec. & Mfg. Co., 300 kw., 125 v., driven by motor and turbine, the latter capable of full load with 250 lb. gage, no superheat steam.
CONDENSER AND AUXILIARIES—C. H. Wheeler Mfg. Co. Two pass, 65,000 sq. ft. with 14,200, ⅞ in. O.D. tubes, 20 ft. long. Phillips type expansion joint; two centrifugal circulating pumps, total head 39.3 ft., combined capacity 76,000 g.p.m., 438 hp. each to drive. Two centrifugal condensate pumps.
CONDENSER TUBES—Revere Copper & Brass, Inc. Admiralty Metal.
CLOSED HEATERS—The Griscom-Russell Co. Low pressure, condensate 88 to 158 deg. F. with 7 deg. F. terminal diff., 2748 sq. ft., ½ in. tubes. High pressure—condensate 263 to 320 deg. F. with 7 deg. F. terminal diff., 2998 sq. ft., ½ in. tubes.
DEAERATING HEATER—Cochrane Corp., outlet capacity 1,200,000 lb. per hr., condensate 158 to 263 deg. F., 0.03 cc per liter oxygen maximum, 5000 gal. storage.
EVAPORATOR—Foster Wheeler Corp. Double effect, normally with 21 lb. gage steam, 30,000 lb. distillate per hour, 0.25 grains per gallon total solids 500 sq. ft. surface each effect.
BLEEDER NON-RETURN VALVES—Schutte & Koerting Co.
ATMOSPHERIC RELIEF VALVE—Atwood & Morrill Co.

BOILER

BOILERS—The Babcock & Wilcox Co. Five 18,010 sq. ft. cross drum type, 260,000 lb. per hr. each, 375 lb. gage, 740 deg. F., with steam scrubber. Interdeck superheater, multiple bend, 5300 sq. ft. Furnace walls, Bailey studded and semi-studded
AIR HEATERS—Ljungstrom for three boilers, Babcock & Wilcox Co. tube type on two boilers. Air leaving at 289 deg. F., gas leaving 495 deg. F.
PULVERIZERS AND BURNERS—Riley Stoker Corp., ten Atrita unit pulverizers 20,000 lb. coal per hour each, 70 per cent through 200 mesh, with magnetic separators. Twenty "Classifying" burners, horizontal turbulent type.
SOOT BLOWERS—Diamond Power Specialty Corp.
DRAFT FANS—B. F. Sturtevant Co., five induced draft, 180,000 c.f.m. at 525 deg. F., 11.2 in. static pressure, vane control. Five forced draft 95,000 c.f.m. at 120 deg. F., 8.7 in. static pressure.
BOILER FEED PUMPS—Worthington Pump & Machinery Corp. Two, 1800 g.p.m. at 450 lb., 1750 r.p.m.; one motor drive; one Terry steam turbine, 600 H.P. with steam at 315 lb. gage, 725 deg. F. or 265 lb. ga. 500 deg. F.
BOILER FEED REGULATORS—Northern Equipment Co. Copes, Double Control.
RAW WATER PUMPS—Ingersoll Rand Co. Two 1000 g.p.m. each, 207 ft. head.
BOILER FEED REGULATORS—Northern Equipment Co. Copes.
ASH SLUICE—The Allen-Sherman-Hoff Co.
PIPING—Midwest Piping & Supply Co. Steam, boiler feed, circulating water, exhaust, vacuum, and condensate piping, manifolds, bends, and insulation.
COAL GATES—Beaumont Birch Co.
BREECHINGS, AIR DUCTS—Connery Construction Co.

Table. II. Data on five new boiler units

BOILER	
Maximum Capacity	260,000 lb./hr.
Heating Surface	18,010 sq. ft.
Design Pressure	375 lb.
Operating Pressure	330 lb.
FUEL	
Pulverized Coal	
Ash Fusion Temp.	1950-2100° F.
FURNACE	
Volume	13,750 cu. ft.
Heat Release	26,000 B.t.u./cu. ft.
Water Cooled Wall	2,523 sq. ft.
SUPERHEATER	
Outlet Temperature	740° F.
At Steam Rate	190,000 lb./hr.
UNITS	5 Units

variable ratings previously mentioned. At prolonged periods of low boiler rating it would be difficult to either maintain or create a molten condition in the ash pit.

Several features of the boiler furnace design, Fig. 3, may be of interest. The major portion of the furnace wall tubes will be semi-studded Bailey type construction except for a patch 7 by 14 ft. in each side wall at the burner level which will be full studded. Bare blocks will be mounted on the hopper floor tubes as well as on the lower side walls. The entire boiler-furnace setting will be encased in steel.

All bottom seven rows of boiler generating tubes are double spaced vertically and the bottom four rows are also double spaced horizontally to act as a slag screen. The superheater is of the return bend type with both inlet and outlet headers outside the flue gas passages. Each boiler will be furnished with an air heater, two of the Babcock & Wilcox tubular type and three of the Ljungstrom rotating type, producing exit air temperatures of 285 deg. F.

Pulverizing equipment will consist of two Riley Atritor mills direct connected to each furnace, each with a capacity of 20,000 lb. coal per hr., or 20 t. of coal per hr. per furnace. This type of mill has previously demonstrated its ability satisfactorily to pulverize coal containing 12 per cent moisture and 16 per cent ash without drying and at low power consumptions and maintenance costs. Burners are of the Riley classifying type, designed to centrifugally return coarse particles to the mill.

In Service this Fall

Turbine and boiler units are now in process of manufacture and it is expected to have the installation ready for operation by November 1st, 1937. The plant extension is being designed by the engineering staff of the Union Electric Light & Power Co. for the Power Operating Co. operators of the station. General work and equipment not purchased "installed and erected" is being handled by Fruin-Colnon contracting Co. as general contractor, and S. C. Sachs Co., Inc., electrical contractor, both of St. Louis, Mo.

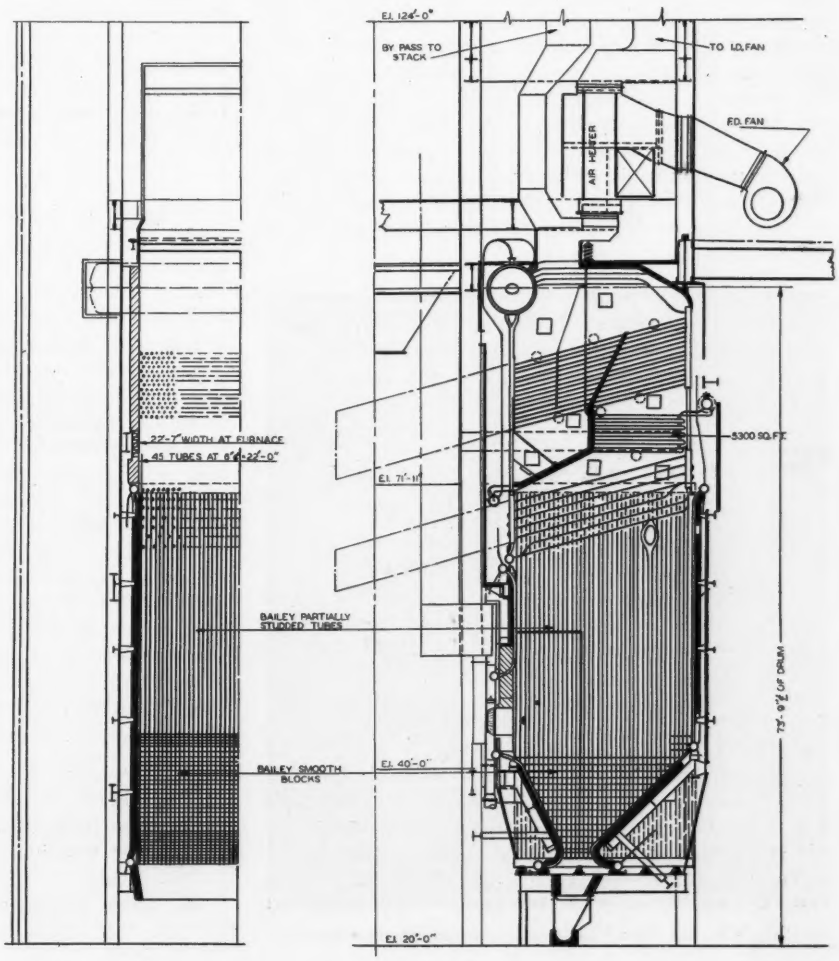


Fig. 3. Cross section of the new boilers. In general these five new units are of the same design as in the former sections. To a boiler surface of 18,010 sq. ft. is added 2,523 sq. ft. of water wall surface and 5,300 sq. ft. of superheater surface. The furnace volume of 13,750 cu. ft. gives a heat release of 26,000 B.t.u. per cu. ft. which past experience has demonstrated as practical for the low fusion ash coal which is in service at the station

Small Steam Turbines—Care and Operation

Mechanical drive turbines are simple and rugged but a little systematic attention is good insurance

By H. W. Newbergh,
Turbine Engineering Dept.,
Elliott Co.,
Jeanette, Pa.

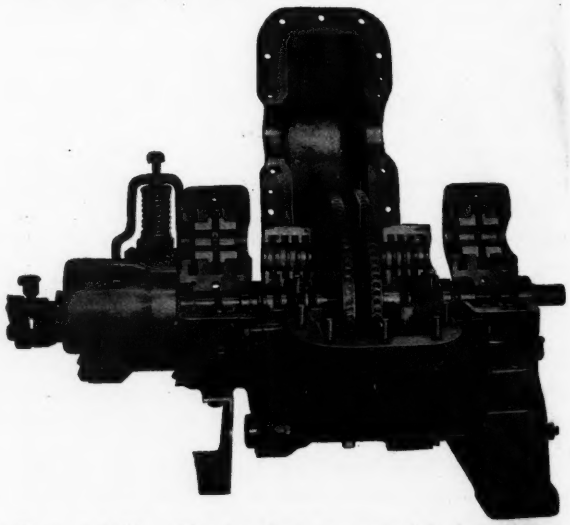


Fig. 1. A turbine with a two-wheel rotor opened for inspection

THAT SPECIES of steam turbine known as the "mechanical drive" has no definite stamping ground in the power plants of the land. Ranging, as they do, from the very threshold of the main operating room floor to the depths of the pump and blower pits and heights of the boiler top, they perform a wide and varying type of service, which combined with an unusual diversity of location, has been a dominant factor in hewing the design down to the present simple and sturdy form. This inherent "built-in" simplicity and ruggedness creates a sense of reliability which, combined with inaccessible locations tending to make maintenance difficult, often reduce care and maintenance to a point below the minimum requirement, with the result that operation may become erratic and repairs expensive.

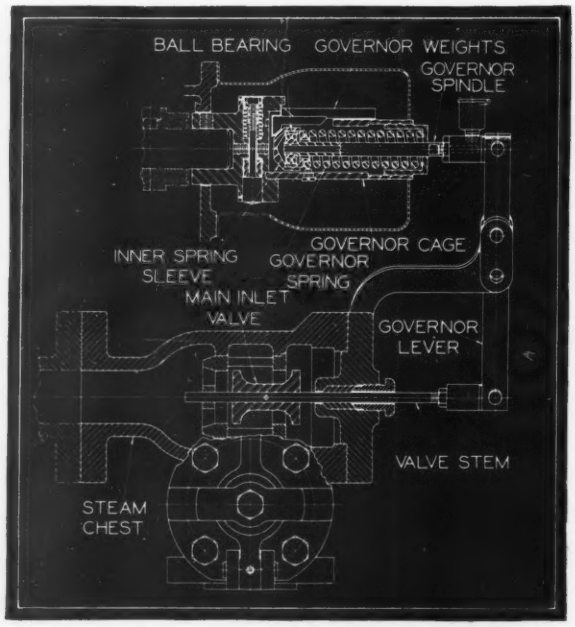


Fig. 2. Section through the steam chest and speed governor

Any system of care and operation which has for its objective an unfailing regularity of inspection and repair and which definitely covers the few vital operating points of this class of turbine must be considered an essential part of any first-class operating schedule. The following discussion of the important points requiring systematic inspection is offered as a brief and minimum outline of a possible inspection schedule which may well be applied to the general group of mechanical drive turbines.

Bearing Lubrication

Bearing lubrication is perhaps the most vital point in the operation of these units, for failure at this point quickly nullifies all other parts of an otherwise most perfect operating schedule. Since both forced-feed and ring-oiled bearings are used on this group, and the latter often with high steam temperatures, particular attention must be directed not only to the quantity of lubricant reaching the bearing surfaces but also to the quality of the lubricant.

The importance of using the highest grade of turbine oil for lubrication of turbines, reduction gears and the driven apparatus cannot be too strongly emphasized. Although the first cost of the best grade of oil may be considerably greater than that of an inferior oil, the additional cost is much more than compensated for by longer service, less danger of damage to bearing surfaces, and the elimination of serious shutdowns due to improper lubrication. There are many reliable manufacturers of oil from whom a first-class turbine oil may be secured, the chief requirements of which should generally be as follows:

1. Properly refined, highly filtered, pure mineral oil.
2. Free from acids and alkalis.
3. Best possible ability to separate rapidly from water.
4. Least tendency to emulsify or foam when agitated with water or air.

5. Least tendency to break down and form sludge when agitated at the actual operating temperature and mixed with air and water.
6. Viscosity as low as is commensurate with operating and constructional conditions involved, in order to reduce bearing friction loss and temperature while still maintaining proper lubrication.

Even though oil of the highest grade is used, it is still important that oil chambers and cavities be regularly cleaned and flushed out and, in so far as possible, water, from leaking glands or other sources, should be prevented from entering the oil chambers.

Governor and Governor Linkage

In general, turbines of this group are fitted with shaft governors which operate at speeds up to 5000 r.p.m. In some cases, the governors are used as speed regulating devices, maintaining the speed of the driven apparatus at a point a few per cent above or below the designed operating speed. In other cases something else, perhaps an excess pressure pump governor regulates the speed and the governor acts only as a speed limiting device. In either case, the function of the governor is undeniably important and since it is at this point that the rotating motion of the shaft must be reduced to a reciprocating motion to impart movement to the governor valve, it is evident that the governor thrust bearing is a critical member requiring frequent inspection and careful adjustment and care.

Since the definite function of the governor is to control the governor valve, either when the speed is being regulated or when the speed is being limited, it is obvious that free movement of the linkage and valve is one of the essential points of satisfactory operation. The governor valve must be practically steam-tight, for when, and if, very light load condition arises and the valve is seated at least momentarily to check the speed, the safe effective functioning of this action depends upon the tightness of the valve on the seat. On some turbines of this class, the governor valve acts also as the emergency tripping valve, and in this case especially is it necessary that the governor valve be absolutely steam-tight.

In reassembling the governor valve or the governor, after disassembly, special care must be taken to see that all parts go together with approximately the same setting as originally obtained and that the final setting of the governor and valve and linkage is such that before the governor reaches its full length of stroke, the steam valve is definitely on its seat.

All parts of the governor linkage, particularly the pins and bushings, must move freely and without too much lost motion, if the function of the governor is to be performed in a proper and safe manner. Any operating schedule must of necessity pay particular attention to all of the detail parts of this linkage and governor valve.

Overspeed Trip, Linkage and Valve

In many ways the overspeed trip linkage and steam valve are similar to the governor linkage and its valve, except that the function of the overspeed mechanism is to definitely stop the steam turbine in the event that any emergency arises. When overspeeding occurs a pin, located in the shaft and with its center of gravity eccentric with the center of the shaft, is restrained by a spring as shown by Fig. 3. At some speed determined by the setting of the resisting spring, centrifugal force causes this pin to fly out and strike a tripping lever, to unlatch a pair of knife edges on a very heavy spring, and close the spring loaded overspeed trip valve.

If the overspeed tripping mechanism is allowed to stand idle for a considerable length of time, it is apparent that corrosion of bushings or sticking of the valve stem may occur. If that happened the mechanism would fail to perform its intended function when an emergency arose, so the operating schedule should pay particular attention to all parts of this linkage. The most satisfactory determination of the proper workability of this entire mechanism is actual overspeeding of the turbine by manually forcing the governor lever (under careful supervision and while taking speed

Keep the turbine in good operating condition by following this inspection schedule

DAILY RECORD AND DUTIES:

1. Observe general operating conditions and vibration of the turbine.
2. Observe bearing temperatures by hand or by thermometer if one is installed, and, the operation of the oil rings or the flow of oil on forced feed lubricating systems. Fill oil reservoirs to the indicated levels. Note oil leaks, if any.
3. Observe governor operation to see that the governor is stable, the linkage free, and no severe governor vibration.
4. Observe each gland for steam leakage along the shaft and if possible, the amount of steam emerging from the gland leak-off.
5. When the turbine is shut down, trip by hand and observe action of the overspeed mechanism and workability of the linkage.
6. Observe turbine speed and, if gage is installed, the ring pressure.
7. Clean unit.

WEEKLY INSPECTION:

1. Inspect oil in bearing cavities and change oil if necessary.
2. Make all minor adjustments and corrections previously noted.

MONTHLY INSPECTION:

1. Change oil in bearing cavities.
2. Roll out bearing shells, inspect babbitt and journals. Measure wear by gauge or micrometer. Inspect thrust faces and clearance and adjust if necessary.
3. Inspect governor wearing parts and make any replacements necessary. Particular attention should be paid to the governor thrust bearing, and its lubrication passages should be cleaned.
4. Test governor and overspeed valves for steam tightness.
5. Inspect overspeed mechanism wearing parts and make any necessary replacements.
6. Inspect carbon gland rings and refit or replace those not having the recommended minimum clearances.
7. Make any corrections or replacements necessary to keep the unit in perfect operating condition.

YEARLY INSPECTION:

1. Lift casing and dismantle all important operating and wearing parts for thorough inspection and cleaning.
2. Inspect interior of the turbine with special reference to nozzles, buckets, wheels and shafts. Clean these parts thoroughly and remove rust. Remove slight corrosion under carbon rings by fine emery cloth.
3. Replace all worn parts and check all clearances and valve and governor settings.
4. Check alignment of turbine with driven apparatus at the coupling and correct if necessary.
5. If unit shows any unusual condition, such as too rapid wear on any part or improper operation, consult the manufacturer of the turbine for information.

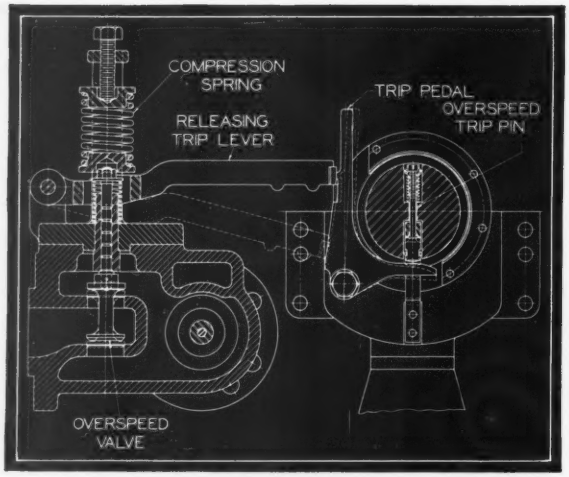


Fig. 3. Section through the overspeed governor

readings with a hand tachometer) until satisfactory turbine shut down is accomplished.

It is considered that an emergency tripping pin operates satisfactorily when it unlatches the tripping mechanism three times in succession at a consistent tripping speed about 10 per cent higher than the normal designed operating speed of the unit, and, the unit shuts down with full throttle pressure on the trip valve. Absolute steam-tightness of the overspeed trip steam valve is an essential to proper safety of operation, and must be checked occasionally.

Glands

Glands may be described as steam retaining rings, fitted between the turbine casing and the shaft at the points where the shaft emerges from the casing, intended to prevent leakage of steam to the atmosphere. They are generally made of carbon rings, located in pockets in a gland case, which closely encircle the shaft and press against the side of each compartment in the gland housing, to prevent the steam from blowing freely along the shaft. Actually, the steam leaks past each gland ring successively, wire-drawing reducing the steam pressure successively. Just before engaging the last carbon ring, the low pressure steam is allowed to escape into a leakoff cavity and piped to the atmosphere, to avoid steam blowing along the shaft.

In themselves, the glands are not an important operating mechanism, but when they cease to perform as designed, they become a menace because they might allow steam to enter the bearing oil cavities, emulsify the oil and cause rapid wear or even destruction of the bearings.

In general, the carbon rings are easily refitted or replaced as recommended by the manufacturer of the particular turbine involved. The point is that these rings definitely should be refitted or replaced whenever leakage of steam along the shaft is such as to endanger the bearings. In the event that a turbine is to be laid up for any length of time, the carbon gland rings should be taken off and allowed to remain disassembled until such time as the turbine is put into use again. During the lay-up period, the shaft, particularly where the carbon rings belong, should be kept slushed with heavy oil to prevent corrosion and sticking. If the carbon rings are allowed to stand in contact with the shaft, for any considerable time, corrosion may occur, probably due to moisture and electrolytic action between the carbon rings and the shaft.

Starting and Stopping

While in the case of this particular group of turbines, starting, from the point of view of warming up, is relatively unimportant, particular attention should always be directed to the possibility of the collection of water in the steam lines or turbine casing. Steam lines ahead of the turbine throttle valve should be well blown down and the casing well drained before starting up. If the unit vibrates under starting conditions it may be that the casing is being distorted by piping strains which should be relieved at the first opportunity. Vibration is a severe tax on both the carbon rings and the governor mechanism and may be the cause of particularly heavy expense in maintenance of these parts.

Trip the overspeed mechanism by hand when shutting down and be sure that the turbine cylinder drain valve is full open so as to avoid an accumulation of water in the casing, with its attendant corrosion of shaft, wheels and buckets. Steam tight throttle and exhaust valves preclude the possibility of water entering the turbine during a shut-down period and, as corrosion preventers, they are worth much to turbine operators.

The accompanying tabulation of inspection and duties would be considered as the minimum requirements for mechanical drive turbines and may be modified or amplified to suit any particular operating schedule or plant. To be of real value, however, observations must be systematically recorded for future reference, for frequent recorded observations offer a clear picture of the operating trend of any particular unit and may well serve as a warning of impending failure, of some wearing part.

The American nickel coin contains three times as much copper as nickel. Nearly 3,000,000 lb. of copper are used annually in minting U. S. coins, including gold and silver pieces. The familiar penny, or "copper," is really made of bronze, containing 95 per cent copper and 5 per cent tin and zinc.

In a telephone conversation between New York and San Francisco 800 tons of copper wire are in use.

A modern 40-ft. motor boat, or cruiser, contains over one million brass screws, mostly in the hull.

In severing the famous Jonker diamond in New York City, a whirling phosphor-bronze disk was used. At 5000 r.p.m. it took days of patient work for the saw, covered with olive oil and diamond dust, to split the gem.

A 5000 yr. old copper frying pan was excavated at Tepe Gawra in 1930. If it were not in the University of Pennsylvania Museum, it could be used for frying eggs today, so little has time affected the enduring metal.

The oldest copper roof, and probably the oldest roof of any kind in America, is the 200 yr. old roof on Christ Church in Philadelphia. Many American patriots worshipped in this historic church, among them George and Martha Washington, Betsy Ross, Benjamin Franklin and Robert Morris. The Marquis de Lafayette was also a regular worshipper there.

MERCURY in Small Boilers

Two small units built to develop 1000 kw. in a mercury turbine plus 900 kw. in a steam turbine open up new, small capacity fields

FOR THE PAST DECADE, the mercury vapor cycle has received serious consideration for power generation because of the high cycle efficiency. The work at Hartford, Kearney and Schenectady has shown what may be accomplished by large installations and has provided a valuable background of practical experience to support future installations.

Perhaps the most interesting development along this line, however, is the application of the mercury vapor cycle to comparatively small plants. During the past year two such installations have been made by the General Electric Co. in its own shops. In each case the installation consists of a mercury boiler, a mercury turbine, a condenser-boiler and a steam turbine.

These embody important modifications in design resulting from experience with the earlier installations. The mercury turbines are rated at 1000 kw. and the condenser boiler supplies 12,500 lb. per hr. of 185 lb. ga. steam, which will be sufficient for the generation of another 900 kw. of electric energy.

The boiler at Pittsfield (Figs. 1 and 2) is of the natural circulation type with tubes similar to the liquid mercury cooling walls in the boilers at Kearny and Schenectady. The unit at Lynn (Figs. 3 and 4) is of the forced circulation type with all the heating tubes filled with liquid mercury and all the vapor formed in a separate chamber remote from the combustion space.

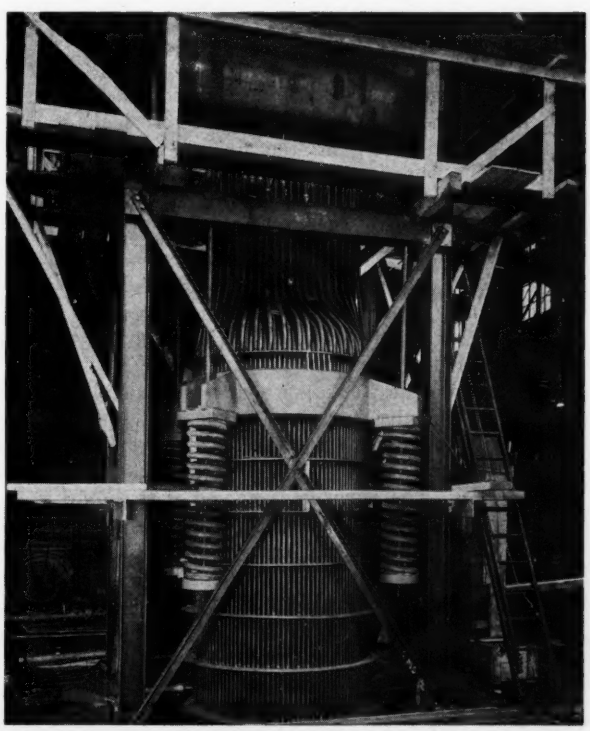


Fig. 1. Tube assembly for the oil fired natural circulation boiler at the G.-E. Pittsfield Works

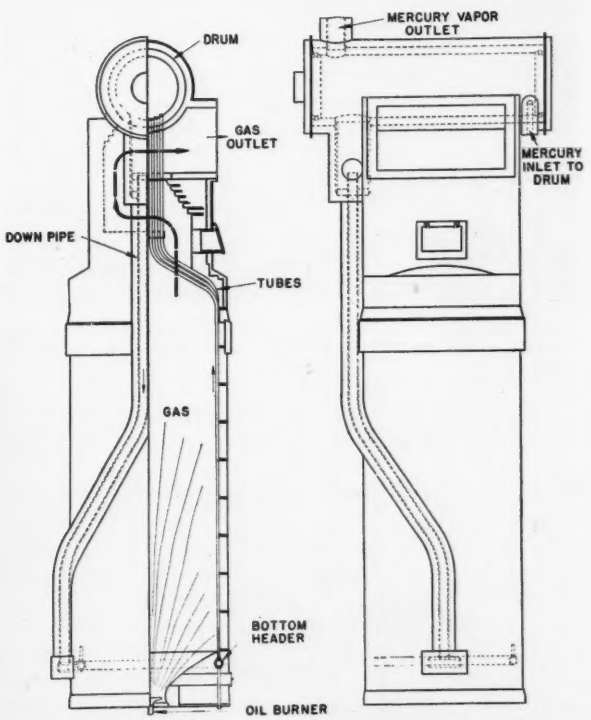


Fig. 2. Semi-section and elevation of the 1900 kw. natural circulation Pittsfield unit shown in Fig. 1.

Vapor is generated by discharging from the heating tubes through a nozzle which drops the pressure and releases the stored heat of the liquid, a portion of which flashes into vapor, the pressure in the heating tubes being approximately 200 lb. per sq. in. greater than that in the flash chamber. This arrangement was evolved to eliminate the transition zone in the combustion space from liquid to vapor, in which difficulty in "wetting" the metal surfaces had been encountered.

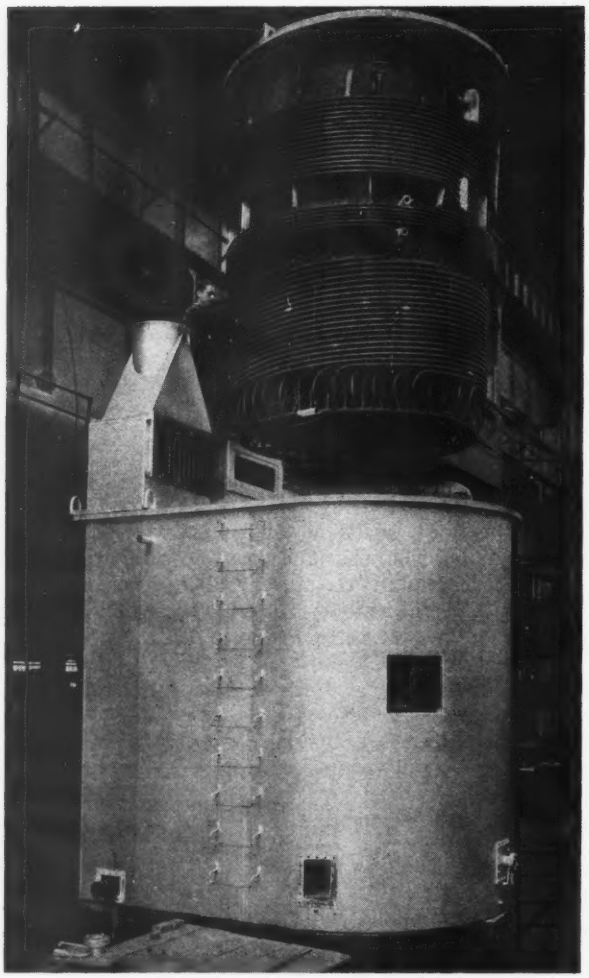


Fig. 3. Furnace, convention, liquid heater and steam superheater tube assembly of the Lynn forced circulation boiler being lowered into the casing

Reviewing the operating difficulties experienced in the earlier installations before the round table study

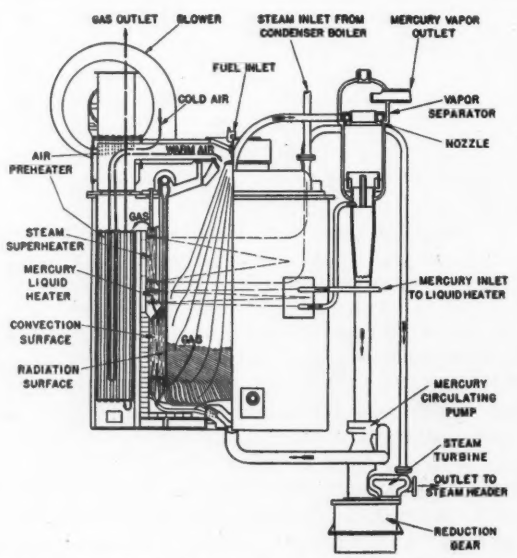


Fig. 4. Semi-section of the 1900 kw. Lynn forced circulation unit

group of the World Power Conference, A. R. Smith of the General Electric Co. classed these under four general headings, namely, leakage, equalization, air infiltration and solubility. The possibility of leaks, even in minute quantities, has necessitated constant surveillance of the stack gases and every such indication necessitated an immediate shutdown. These difficulties have been now overcome by progress in welding.

Avoidance of excessive investment requires maintenance of a low liquid level in the seven drums, and, in order to make sure that no drum will fail to feed its porcupine tubes, it has been necessary to provide for careful maintenance of levels and adequate communicating passages have been necessary. A simpler boiler with only one drum has now been designed to overcome these objections.

Another source of difficulty has been occasional overheating of certain tubes due to non-wetting by the liquid. This was the result of air infiltration and contamination of the mercury by oxide formation. Deoxidating agents introduced into the mercury remedied this non-wetting condition but caused lumping of the

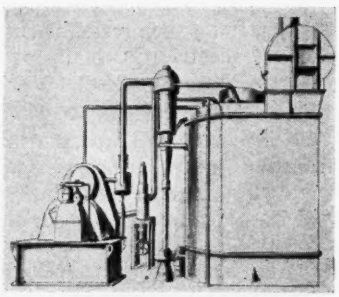


Fig. 5. What a small mercury installation will look like set up for business

products of oxidation so as to stop up some of the tubes. Now, however, a design of liquid mercury shaft packing has been evolved which has zero leakage and in the Schenectady plant the air infiltration from all sources has been reduced from 200 or 300 cu. ft. per hr. to less than 1 cu. ft. per hr.

While there have been no shutdowns due to the tendency of the mercury to dissolve the materials, laboratory investigations have proved that solution of the steel may be inhibited by certain agents, as a result of which small quantities of zirconium are now being added to the mercury.

Design sketches for a mercury-steam installation of 44,000-kw. capacity have been made, and employs but a single drum. Moreover, there are no dead-ended porcupine tubes, which are difficult to clean, and no water walls. The furnace is cooled with liquid mercury tubes, in the upper length of which vaporization occurs. In the upper and cooler part of the combustion chamber are arranged a series of fog bank tubes from which the products of combustion pass through a liquid heater before reaching the steam superheater and air preheater on their way to the stack.

It was stated that at Schenectady and Kearny 7½ lb. of mercury are required per kilowatt of capacity, whereas the new designs require about 6 lb. The Kearny guarantee was 9500 B.t.u. per kw. hr.

SUPERPOSITION

C. W. E. Clarke, Consulting Engineer, Outlines Some of the Factors in This Trend Before the Philadelphia Section of the A. S. M. E.

RAPID increase in the use of higher steam pressures and temperatures in the production of power for industrial and utility use has resulted in the installation of a large number of so-called Superposed Generating Units.

Superposing of generating units, that is, the use of a generating unit at a pressure range different from the range of the existing units, is in fact rather old practice. The installation of low-pressure turbines in connection with engine-driven units, while placed at the bottom of the cycle and operated from the original boiler plant, is substantially the same as superposing. The use of the steam turbine extended the heat range materially by allowing the use of low vacuum, thus improving the over-all economy of the installation.

One of the early installations of this character was the 7500 kw. units in the 59th St. Station of the Interborough Rapid Transit Co., New York, in November 1909. Superposing as we know it today, however, had its real beginning about 1925, with the installation of a 3000 kw., 1200 lb. unit at Edgar Station in Boston.

The reason for the present-day development are interesting and varied, but without doubt the primary impulse was given by the desire on the part of engineers everywhere to improve the steam cycle, a desire which has been evident ever since Watts' time.

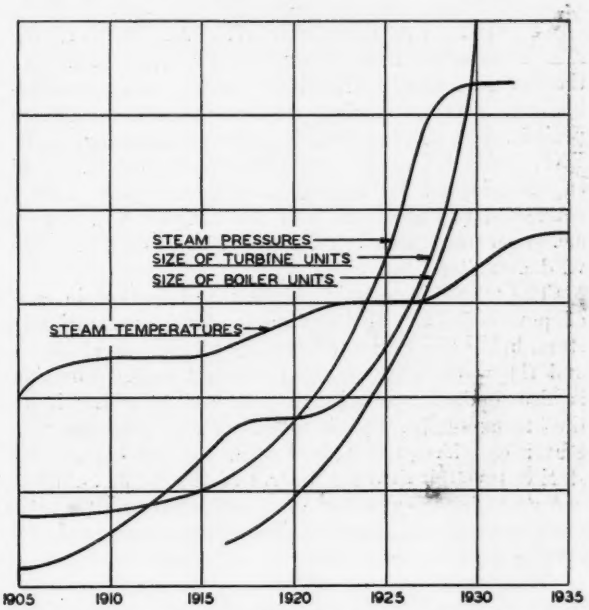
It is only recently, however, that engineers really have known enough about the actual theory of the steam cycle to properly cope with the problem. In the course of a more or less blind fumbling for improvement, the steam engine passed through a cut-and-try development of years and it was not until the advent of the steam turbine, early in the 20th century, that thought and research really started along the lines of intensive development of the steam cycle. Always, it seems to me, the prime mover has kept considerably in advance of the steam-producing medium.

Many of us can look back to a period when boiler installations were made with little thought as to actual combustion efficiency, although prime mover efficiency was much sought after. The advent of the steam turbine acted as a spur to power development to a greater extent than anything the art has experienced in many years, speeding up improvement in a remarkable degree; and with prime mover development, hand-in-hand and aided thereby, went improvements in boiler construction, in combustion methods and in electrical distribution.

One constant bar to progress was a noticeable lag in the improvement of materials. As soon as proper materials were available or methods of manufacture were favorable for advancement, increased pressures and temperatures in the steam cycle followed promptly. Early results were so beneficial that they acted as a further spur to development, resulting in the high-pressure and high-temperature cycles of today.

Most important of all the developments has been the introduction of welding, allowing as it does, the pressure parts of boilers and all joints in the high-temperature and high-pressure piping systems to be welded, thus avoiding almost completely the use of flanged joints, gaskets and bolting material.

Between 1921 and 1930 there were installed approximately 14,000,000 kw. in generating plants of the utility field. A fairly large percentage of this is today uneconomical from a heat-consumption viewpoint but is in good physical condition for reliable operation and can be brought up to date and taken out of the class of peak load capacity by superposing generating units over the present capacity.



Graphical Representation of Changing Conditions in the Power Field During Recent Years

Possibilities of the industrial field, although in the main restricted to the use of relatively small units, are even greater than in the utility field. Large numbers of industrial steam plants are old and of low operating pressures and temperatures. Modern industrial processes of many kinds require the use of relatively large quantities of process steam at various pressures and in the replacement of these old steam generating plants, it should be comparatively easy in a large number of cases to justify generating units to supply the low-pressure process steam.

It might be pertinent to consider what tangible benefits these superposed units have given the operating companies. Their value may be said to be twofold: The installation of superposed units gives new life to older installations whose equipment, while satisfactory from reliability standpoint, nevertheless is sadly lacking in thermal efficiency. In the case of industrial installations the superposing of generating units over processes provides kilowatts and steam at a minimum heat consumption when it is considered that one or the other is of a byproduct nature.

DIESELS for Automatic Standby

Pittsburgh Plate Glass Co. utilizes standard equipment for automatic engine starting upon power failure. Load transferred in from 15 to 30 sec.

By Harvey R. Artman, Pittsburgh Plate Glass Co.

AT THE CLARKSBURG, W. VA., PLANT, the Pittsburgh Plate Glass Co. has just completed the installation of a Diesel generating unit for standby a.c. service during central station shutdown periods. The driving unit is a Cooper-Bessemer Type EN6, vertical, 6 cyl., 4 cycle, 300 hp., 900 r.p.m. Diesel engine adapted for operation on natural gas. Direct connected to the engine is a 200 kw., 0.8 p.f., 240 v., a.c. generator which in turn is V-belted to a 5 kw., 125 v., d.c. exciter.

The whole installation is arranged so that in case of power failure, the gas engine will automatically start, bring the generated voltage to the proper value, and throw the unit on the plant bus bars. Provision is also made for starting engine and throwing it on the bus manually. In this case the standby engine generator can be synchronized with the system central station through throttle control of the engine. At the end of each run, whether from a manual or automatic start, the engine must be shut down by hand as shown by Fig. 5.

With the exception of 2 relays, the entire installation consists of standard equipment, which simplifies the problem of upkeep and replacement.

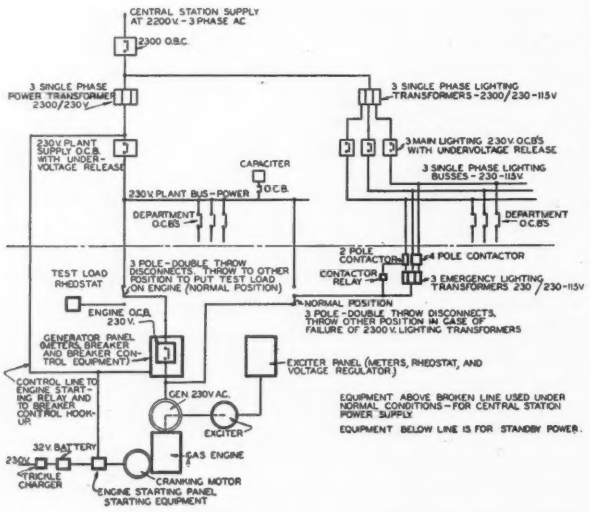

CENTRAL STATION SUPPLY AT 2200 V.-3 PHASE AC
2300 O.B.C.
3 SINGLE PHASE POWER TRANSFORMER 2300/230 V.
3 SINGLE PHASE LIGHTING TRANSFORMERS-2300/230-115 V.
230 V. PLANT SUPPLY O.C.B. WITH UNDER-VOLTAGE RELEASE
3 MAIN LIGHTING 230 V. O.C.B'S WITH UNDERVOLTAGE RELEASE
CAPACITER
3 SINGLE PHASE LIGHTING BUSSES-230-115 V.
230 V. PLANT BUS-POWER O.C.B.
DEPARTMENT O.C.B'S
DEPARTMENT O.C.B'S
2 POLE CONTACTOR
4 POLE CONTACTOR
TEST LOAD RHEOSTAT
3 POLE-DOUBLE THROW DISCONNECTS THROW TO OTHER POSITION TO PUT TEST LOAD ON ENGINE (NORMAL POSITION)
CONTACTOR RELAY
3 EMERGENCY LIGHTING TRANSFORMERS 230/230-115 V.
NORMAL POSITION
3 POLE-DOUBLE THROW DISCONNECTS. THROW OTHER POSITION IN CASE OF FAILURE OF 2300 V. LIGHTING TRANSFORMERS
ENGINE O.C.B. 230 V.
GENERATOR PANEL (METERS, BREAKER AND BREAKER CONTROL EQUIPMENT)
EXCITER PANEL (METERS, RHEOSTAT, AND VOLTAGE REGULATOR)
CONTROL LINE TO ENGINE STARTING RELAY AND TO BREAKER CONTROL HOOK-UP
GEN. 230 V. AC.
EXCITER
EQUIPMENT ABOVE BROKEN LINE USED UNDER NORMAL CONDITIONS-FOR CENTRAL STATION POWER SUPPLY
EQUIPMENT BELOW LINE IS FOR STANDBY POWER.
32 V. BATTERY
230 V.
GAS ENGINE
TRICKLE CHARGER
CRANKING MOTOR
ENGINE STARTING PANEL STARTING EQUIPMENT

Fig. 1. Line diagram of the a.c. power layout, showing the essentials of the original equipment for supply by central station power and the hookup with the new standby power system

At the Mt. Vernon, O., plant of the Pittsburgh Plate Glass Co. there has been a similar standby power system in service for about a year with very satisfactory results. The driving unit in that installation is a Type EN6, vertical, 6 cyl., 4 cycle, 275 hp., 720 r.p.m. Cooper-Bessemer gas engine, direct connected to a 175 kw., 720 r.p.m., 240 v., 3 ph., 60 cycle, 0.8 p.f. generator belted, by a Texrope drive to a 5 kw., 125 v., d.c., 1750 r.p.m. exciter. The installation is arranged almost exactly like the Clarksburg installation described in detail below, the main difference being in the engine speed, and consequently, the system output.

Requirements

Efficient and reliable operation of an automatic standby generating unit entails satisfactory solutions of several problems.

Table I. Equipment used for engine starting system. The names refer to items similarly marked on Fig. 2

Selector Switch—Square D Co. Type LB-2 No. 9002 W 51.
Engine Starting Under Voltage Relay—Cutler-Hammer Co. No. 320, Item 3 Relay, 220 v., a.c. Normally closed type.
Auxiliary Switch—Condit Co. Q 7, auxiliary switch shown as 1 of 4 stages.
Stop Cranking Relay—Cutler-Hammer Co. No. 320. Item 3 Relay, 115 v. continuous rating, to pick up at 50 v., d. c Normally closed type.
Notching Relay—Built by P. P. G. Co.
Motor—Dumore Co. Type XAD Geared 25 v., d.c., 1081 to 1 gear ratio, slow speed shaft, 3-1/3 r.p.m. Pulley added to reduce speed to 1 r.p.m.
Switches—G. E. Vapor Lamp Co., single pole, single throw, No. 7-21-KR-1 mercury switches.
Battery Contactor—Square D Co. 300 Amp. single contactor. Special—20 v., d.c. coil, carbon to carbon contacts.
Gas Valve—Ruggles-Klingemann Co., solenoid trip valve, 2 in. Fig. 229 A, 20 v., d.c. coil, suitable for inverted mounting, with normally open contact for lighting indicating lamp.
Water Valve—Ruggles-Klingemann Co. Fig. 229 A, 1¼ in. same as gas valve.

Starting. Instant starting involves exact control of the fuel supply and cranking operations. Regulation of the gas to supply the engine at constant atmospheric pressure produces the most efficient mix of air and gas. Controlled cranking is obtained through a special notching relay, Fig. 3, designed and built by the owners. It provides for six alternate "on and off" cranking periods, totalling 1 min. After this the relay locks out and must be reset by hand. This feature prevents indefinite futile cranking and a run-down starting battery.

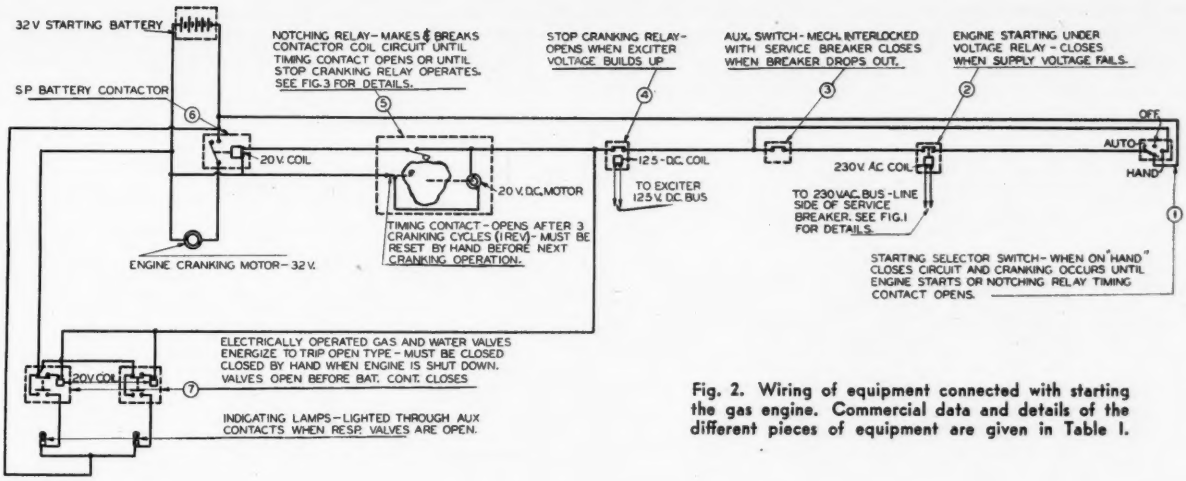

32 V STARTING BATTERY
NOTCHING RELAY - MAKES & BREAKS CONTACTOR COIL CIRCUIT UNTIL TIMING CONTACT OPENS OR UNTIL STOP CRANKING RELAY OPERATES. SEE FIG. 3 FOR DETAILS.
STOP CRANKING RELAY - OPENS WHEN EXCITER VOLTAGE BUILDS UP
AUX. SWITCH - MECH. INTERLOCKED WITH SERVICE BREAKER CLOSES WHEN BREAKER DROPS OUT.
ENGINE STARTING UNDER VOLTAGE RELAY - CLOSES WHEN SUPPLY VOLTAGE FAILS.
S.P. BATTERY CONTACTOR
20 V. COIL
20 V. D.C. MOTOR
125 - D.C. COIL
TO EXCITER 125 V. D.C. BUS
230 V. AC. COIL
TO 230 VAC. BUS - LINE SIDE OF SERVICE BREAKER. SEE FIG. 1 FOR DETAILS.
OFF
AUTO
HAND
TIMING CONTACT - OPENS AFTER 3 CRANKING CYCLES (1 REV) - MUST BE RESET BY HAND BEFORE NEXT CRANKING OPERATION.
ENGINE CRANKING MOTOR - 32 V.
STARTING SELECTOR SWITCH - WHEN ON "HAND" CLOSES CIRCUIT AND CRANKING OCCURS UNTIL ENGINE STARTS OR NOTCHING RELAY TIMING CONTACT OPENS.
ELECTRICALLY OPERATED GAS AND WATER VALVES ENERGIZE TO TRIP OPEN TYPE - MUST BE CLOSED CLOSED BY HAND WHEN ENGINE IS SHUT DOWN. VALVES OPEN BEFORE BAT. CONT. CLOSES
20 V. COIL
INDICATING LAMPS - LIGHTED THROUGH AUX CONTACTS WHEN RESP. VALVES ARE OPEN.

Fig. 2. Wiring of equipment connected with starting the gas engine. Commercial data and details of the different pieces of equipment are given in Table I.

INTERLOCKING. Automatic starting of the engine, only after the service breaker has dropped out due to central station failure, is accomplished through interlocking with the breaker and supply bus. Similar interlocking prevents the standby breaker going on the line automatically if plant bus is not dead.

VOLTAGE REGULATION. A special voltage relay built to the owner's specifications insures standby voltage going on the plant bus only when it has reached the correct value. Pre-set exciter and alternator field rheostats insure the generator building up to normal load voltage. A standard voltage regulator provides within plus or minus two per cent of normal voltage while the engine is operating under load.

PROTECTION. Automatic protection of the engine by shut-down is afforded through mercoid switches on both cooling water and lubricating oil systems and by a mechanical overspeed stop. An alarm bell gives an indication of engine shut-down by any of above devices.

METERING. Adequate metering equipment includes frequency meter, voltmeter, ammeter and watt-hour meter on the a.c., voltmeter and ammeter on the exciter d.c. and a d.c. voltmeter on the starting battery.

MAINTENANCE. Reliable operation of the engine is promoted through a regular weekly check-up of the equipment as a matter of maintenance routine, even to a run on a test load giving the equivalent of normal plant load to be expected.

POWER SUPPLY. A 32 v. storage battery provides power for the operation of notching relay, battery contactor, cranking motor and electrically-opened valves, all connected with engine starting. This 32 v. battery voltage is maintained under constant trickle charge from the 230 v., d.c. plant bus. The exciter d.c. voltage provides power for operation of the standby breaker. Thus the essential power supplies for engine operation are taken care of independent of the plant services.

SEQUENCE OF OPERATION

Upon failure of the central station supply, an undervoltage relay in the starting circuit closes instantly. The service breaker, being equipped with a time delay undervoltage release to ride out momentary surges, does not drop out until after 2 sec. This closes an auxiliary switch which completes the circuit to trip open water and gas valves and start the notching relay. When the relay contact closes, the battery contactor picks up, and current is supplied to the starting motor to crank engine. As the exciter voltage builds up it operates a relay to break the cranking circuit.

As soon as generated voltage has built up to proper value to go on the line, a special voltage relay closes the circuit through the control relay, which picks up and energizes the solenoid breaker closing mechanism. Breaker auxiliary switches operate at same time to de-energize the relay coils, set up the breaker trip circuit and operate the field rheostat sectionalizing contactor.

Transfer of plant load from purchased power to the standby supply is thus completed in a period of 15 to 30 sec., depending on the setting of the time delay undervoltage relay.

FLEXIBILITY

To start the engine by hand for a test run or for actual power supply when notice of central station shutdown is given, it is only necessary to throw the starter selector switch to "Hand." The engine speed

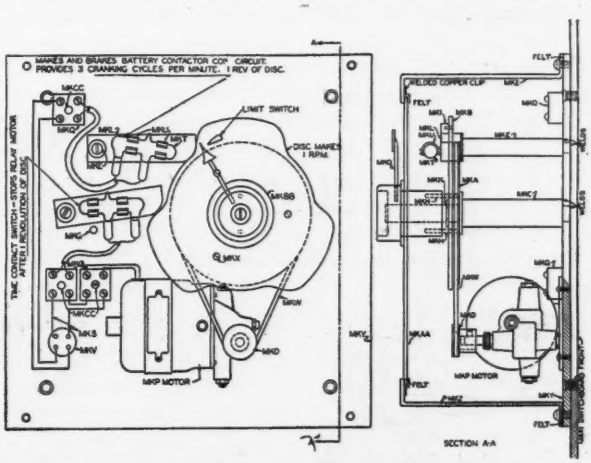

MAKES AND BRAKES BATTERY CONTACTOR COIL CIRCUIT. PROVIDES 3 CRANKING CYCLES PER MINUTE. 1 REV OF DISC.
LIMIT SWITCH
DISC MAKES 1 R.P.M.
MKP MOTOR
SECTION A-A

Fig. 3. Arrangement of the special notching relay used for controlling the cranking of the engine

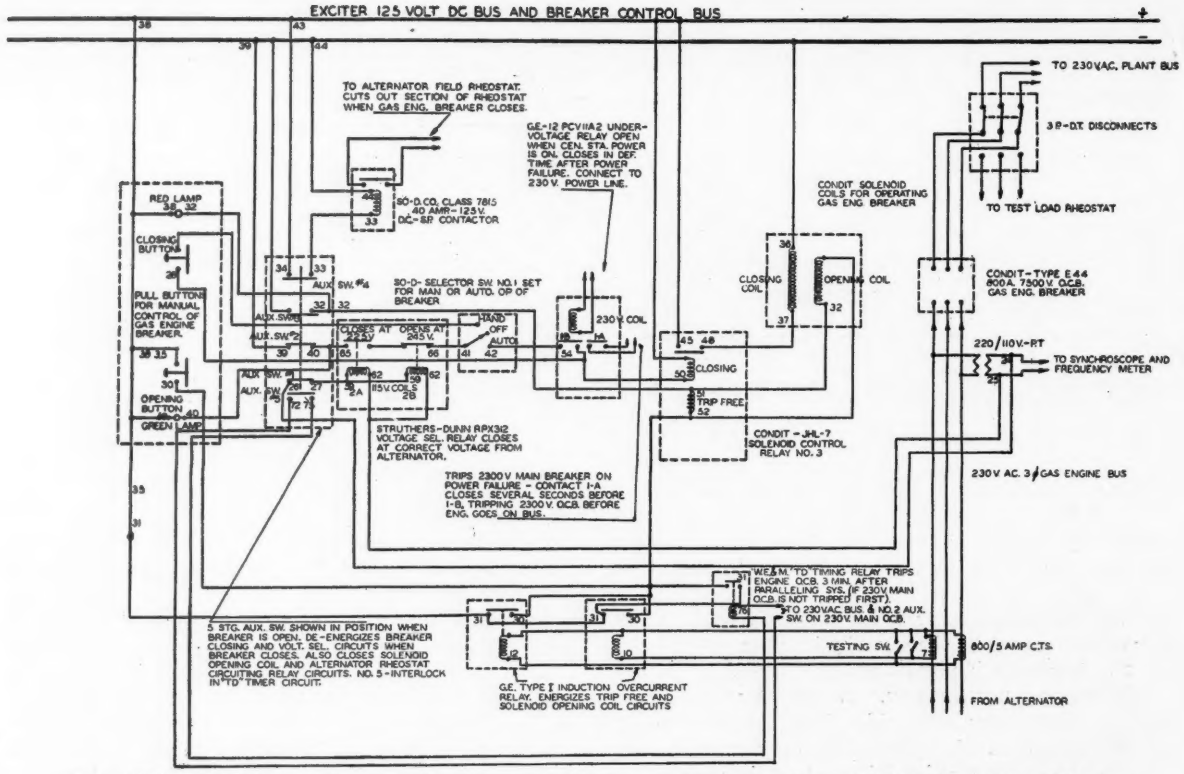

EXCITER 125 VOLT DC BUS AND BREAKER CONTROL BUS
TO ALTERNATOR FIELD RHEOSTAT. CUTS OUT SECTION OF RHEOSTAT WHEN GAS ENG. BREAKER CLOSES.
GE-12 PCV11A2 UNDER-VOLTAGE RELAY OPEN WHEN CEN. STA. POWER IS ON. CLOSES IN DEF. TIME AFTER POWER FAILURE. CONNECT TO 230 V. POWER LINE.
TO 230 VAC. PLANT BUS
3 P-D.T. DISCONNECTS
TO TEST LOAD RHEOSTAT
CONDIT SOLENOID COILS FOR OPERATING GAS ENG. BREAKER
RED LAMP
CLOSING BUTTON
PULL BUTTON FOR MANUAL CONTROL OF GAS ENGINE BREAKER.
OPENING BUTTON
GREEN LAMP
50-D.CO. CLASS 7815 40 AMP-125 V. DC-6P CONTACTOR
AUX. SW. #4
AUX. SW. #2
AUX. SW. #1
AUX. SW. #3
50-D- SELECTOR SW. NO. 1 SET FOR MAN. OR AUTO. OP. OF BREAKER
CLOSES AT 225 V.
OPENS AT 245 V.
MAN'L
OFF
AUTO
230 V. COIL
115 V. COIL
CLOSING COIL
OPENING COIL
CONDIT-TYPE E 44 600 A. 7500 V. O.C.B. GAS ENG. BREAKER
220/110 V.-RT
TO SYNCHROSCOPE AND FREQUENCY METER
CLOSING
TRIP FREE
CONDIT-JHL-7 SOLENOID CONTROL RELAY NO. 3
STRUTHERS-DUNN RPX312 VOLTAGE SEL. RELAY CLOSES AT CORRECT VOLTAGE FROM ALTERNATOR.
TRIPS 2300 V MAIN BREAKER ON POWER FAILURE - CONTACT 1-A CLOSES SEVERAL SECONDS BEFORE 1-B, TRIPPING 2300 V. O.C.B. BEFORE ENG. GOES ON BUS.
230 V AC. 3 ϕ GAS ENGINE BUS
W.E. & M. "TD" TIMING RELAY TRIPS ENGINE O.C.B. 3 MIN. AFTER PARALLELING SYS. (IF 230 V. MAIN O.C.B. IS NOT TRIPPED FIRST).
TO 230 VAC. BUS & NO. 2 AUX. SW. ON 230 V. MAIN O.C.B.
TESTING SW.
800/5 AMP C.T.S.
FROM ALTERNATOR
5 STG. AUX. SW. SHOWN IN POSITION WHEN BREAKER IS OPEN. DE-ENERGIZES BREAKER CLOSING AND VOLT. SEL. CIRCUITS WHEN BREAKER CLOSES. ALSO CLOSES SOLENOID OPENING COIL AND ALTERNATOR RHEOSTAT CIRCUITING RELAY CIRCUITS. NO. 5 - INTERLOCK IN "TD" TIMER CIRCUIT.
G.E. TYPE I INDUCTION OVERCURRENT RELAY. ENERGIZES TRIP FREE AND SOLENOID OPENING COIL CIRCUITS

Fig. 4. Wiring detail of the equipment and panels connected with manual and automatic operation of the engine and breakers

is then adjusted through a motorized governor control to the point where the two systems are in synchronism as indicated on a synchroscope. Standby generated power is then thrown on the bus by operating the closing pull button, and tripping the service breaker by hand.

When notice of central station supply resumption is given, engine speed control is effected from main switchboard through motor-driven governor. At synchronism, the service breaker is closed manually and engine breaker is tripped after 3 min. by a timing relay, to prevent indefinite parallel operation of the two systems. Engine must be shut down and valves closed by hand, after which selector switches and notching relay are reset for automatic operation.

Single phase a.c. for emergency lighting is obtained through transformers fed from either a.c. supply. They are connected so as to go on the engine bus before the power transfer is completed and thus serve as a balancing load until the plant power load is applied. An alarm bell sounds from the moment of power failure until an electrician checks on the operation of the equipment.

Summary

During normal power supply, the a.c. lighting and power loads are fed through transformers from the central station, and the d.c. load is fed from a d.c. bus supplied from a M.G. set. On power failure, d.c. load is transferred to a 120 cell, 20 kw. battery, good for 1 hr., and the essential a.c. loads to the gas engine. After the a.c. transfer has been completed, the d.c. load can be supplied from the M.G. set, instead of the battery. The gas engine can also be used in case of power transformer failure, while the emergency lighting transformers can be used in case of lighting transformer failure and be fed from the normal a.c. supply.

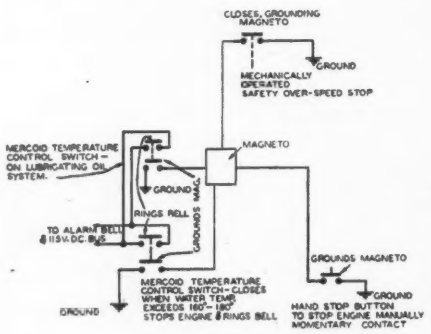
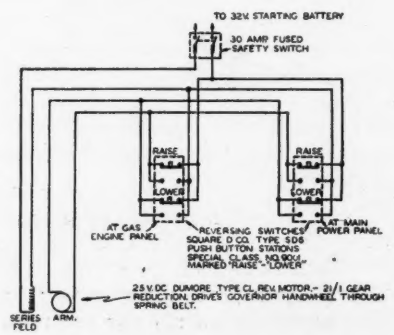

CLOSES, GROUNDING MAGNETO
GROUND
MECHANICALLY OPERATED SAFETY OVER-SPEED STOP
MERCOID TEMPERATURE CONTROL SWITCH - ON LUBRICATING OIL SYSTEM.
MAGNETO
GROUND
RINGS BELL
GROUNDS MAG.
TO ALARM BELL & 115 V. DC. BUS
GROUNDS MAGNETO
GROUND
GROUND
MERCOID TEMPERATURE CONTROL SWITCH - CLOSES WHEN WATER TEMP. EXCEEDS 160°-180° STOPS ENGINE & RINGS BELL
HAND STOP BUTTON TO STOP ENGINE MANUALLY MOMENTARY CONTACT

Fig. 5. (Left) Hookup for protection of the engine and for manually stopping the engine

Fig. 6. (Right) Motor wiring for speed control while synchronizing the engine with the utilities system


TO 32 V. STARTING BATTERY
30 AMP FUSED SAFETY SWITCH
RAISE
LOWER
RAISE
LOWER
AT GAS ENGINE PANEL
REVERSING SWITCHES SQUARE D CO. TYPE 506 PUSH BUTTON STATIONS SPECIAL CLASS NO. 9001 MARKED "RAISE - LOWER"
AT MAIN POWER PANEL
25 V. DC. DUMORE TYPE CL. REV. MOTOR - 2I/1 GEAR REDUCTION. DRIVES GOVERNOR HANDWHEEL THROUGH SPRING BELT.
SERIES FIELD
ARM.

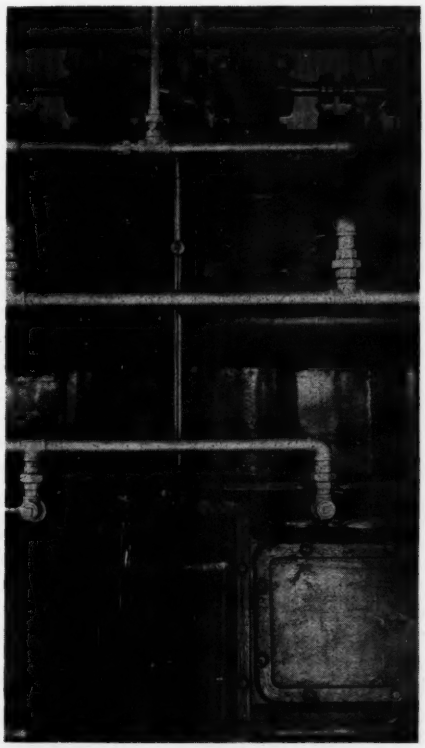
Jacket Piping Change Aids Cleaning

By Elton Starrett

AS ORIGINALLY CONNECTED up for cooling, water inlets on a battery of 200 hp. vertical gas engines were made up of 1½ in. pipe, branching downward to reach the bottom of the water jacket and terminating in street ells screwed into the engine casting itself. One union, midway of the two inlets, facilitated dismantling of the line.

Corrosion made it imperative to switch over to local surface water for cooling the engines and the fine silt tended to deposit and build up solid blocks in the eddies and still sections of the water jacket. This caused uneven cooling of the cylinder, with consequent excessive and spotty wear and irregular distribution of lubrication.

Engine jackets required frequent cleaning, from



Replacing street ells with tees simplified draining and cleaning this engine water jacket

every 2 wk. during the rainy season to as many months during the summer, and involved dismantling the entire inlet system from the control valve to the main casting each time. Consequent wear on the threads, and greater take-up needed each time on every joint to insure tightness and to line up, put the line under unnecessary strain and leaks were frequent.

To enable mud and silt to be flushed from the jacket without dismantling the inlet line, the engineer in charge pulled the two street ells and replaced them with tees, closing the outer end of each tee with a plug to provide a readily opened drain for the wash-out water. Then, by using two unions where but one had formerly been considered adequate, and placing one immediately above each tee, he was able to remove the entire inlet line as a rigid unit. Since revising the inlet lay-out, the wash-out job involves only the removal of two plugs.

New California Pipe Line

Four New Steam Driven Pumping Stations and Improvements in Six Old Stations Involved in $4,500,000 Construction Project by the Shell Oil Co.

CONSTRUCTION of 258 miles of 10 and 12 in. pipe line with necessary laterals has just been completed by the Shell Oil Co. from Bakersfield to the Martinez Refinery. This line will have four new pumping stations and, for part of the distance, will parallel an old line from Coalinga to the refinery. Designed for a wide range of oils and temperatures, the 10 in. line leaving the station is increased to 12 in. about two-thirds of the distance to the next pumping station. The maximum temperature of 180 deg. F. and 1000 lb. operating pressure is intended to give a capacity of 1200 bbl. per hr.

Each of the four new stations is provided with three Ingersoll-Rand, 4-stg., 6 in. centrifugal pumps driven by 350 hp. Moore turbines. Steam is supplied by three 238 hp. Heine boilers, operating at 200 lb. pressure, 100 deg. superheat. Boilers are fired by gas or with oil standby.

Auxiliary equipment includes two Ingersoll-Rand 2-stg., 80 g.p.m., 275 lb. centrifugal boiler feed pumps and two 80 g.p.m. 70 ft. head feedwater heater supply pumps, all steam driven. Feed water is heated in an Elliott deaerating heater with a capacity of 30,000 lb. per hr. from 140 to 219 deg. F. A 7x5x10 in. steam pump is provided for general utility service, and a 300 g.p.m. centrifugal pump driven by a steam turbine installed as a fire pump. Equipment is housed in a steel frame corrugated iron building, 59 by 100 ft. Boilers and auxiliaries are separated from the pump room by a fire-proof wall.

Oil heaters in each station consist of: two, 48 in. diameter by 20 ft. tube length low pressure heaters, each with a heating surface of 6225 sq. ft.; and, one high pressure heater, 26 in. in diameter by 18 ft. tube length with 1422 sq. ft. of heating surface.

The old 8 and 10 in. line from Coalinga to Martinez was originally built for a capacity of 1000 lb. per hr. at 800 lb. pressure with a maximum temperature of 140 deg. F. This was increased to 180 deg. F. by installing, in the six old pumping stations, new heaters similar to those in the four new stations, and, adding one 238 hp. Heine boiler. Provision was also made to change from oil to gas fuel with oil as a standby.

All engineering was handled by the Shell Oil Co. under the supervision of Chief Field Engineer J. R. Gignoux. The construction was performed under contract, but seven months being required from the original engineering studies to the completion of the line. Oil was started from Bakersfield at 8:00 a. m. December 2 and arrived at the refinery at 5:15 p. m. December 27.

Electron

Ready for Naval Inspection

Part of a large shipment of G.E. Tungar Bulbs for the U. S. Navy.

THE ADDITION of the screen grid to the triode, as was shown in the preceding article, while removing the limitation due to capacity effect at the same time causes another undesirable effect which limits the usefulness of the tube in other ways. This is the effect due to secondary emission, i.e., the "splashing out" of electrons from the plate by the impact of the high velocity primary electrons. The effect, of course, also occurs in the ordinary triode but there the secondary electrons are repelled and driven back to the plate by the field of the control grid, which usually is operated at a negative potential. In the screen grid tube, however, the positively charged screen grid attracts the secondary electrons and causes a reverse current to flow under certain conditions of screen and plate potential. This, obviously, is undesirable and seriously limits the screen grid tube's use as a power amplifier. With alternating potential on the plate, when the swing in plate voltage reduces its value to something about the same as that of the screen grid, the plate current suddenly drops to almost zero. This, we have seen, is the result of secondary emission—of the attraction of the secondary electrons by the screen grid. Obviously if the secondary emission could be suppressed or inhibited, the usefulness of the tube could be greatly extended.

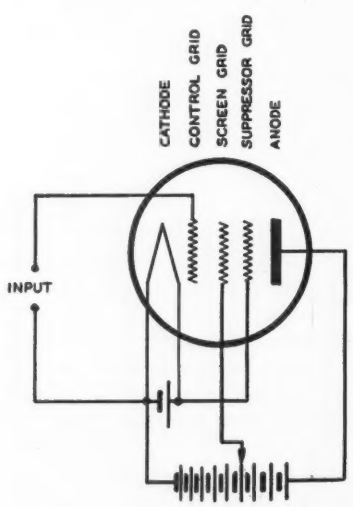


Fig. 1. This is how the five elements in the pentode are usually disposed and connected in the circuit. The connection between the suppressor grid and the cathode is often made within the tube itself

This is actually accomplished in the pentode. The pentode, as its name implies, is a five element tube, one having three grids. This third grid is placed between the screen grid and the plate as indicated in Fig. 1 and its function is to prevent the secondary electrons from reaching the screen grid. It is, therefore, called the suppressor grid. It is connected directly to the cathode or to a point of zero potential and because of its low potential repels the relatively low velocity secondary electrons back into the plate without appreciably obstructing the primary electrons speeding from the cathode to the plate. As a consequence, with a tube of this kind the, so-called, negative resistance region[1] of the screen grid tetrode is eliminated. This tube has approximately the characteristics of the screen-grid tube without its limiting features. Large, undistorted power outputs can be secured from the pentode. The connection between the suppressor grid and the cathode is usually permanently made within the tube structure.

The principle of secondary emission is illustrated in Fig. 2 and its action in the three types of tubes (the

[1]That part of the plate current characteristic where the plate current decreases with an increase in plate voltage or in general, that portion of the curve where the plate potential is less than the screen grid potential.

Tubes—
Principles and Applications

PART XIV

What is a Pentode? A Suppressor Grid? Secondary Emission? As explained in this article these formidable terms are not as terrifying as they sound and quite easy to understand. This article explains the action of the suppressor grid in the pentode, simply and clearly. The basic principles of the X-ray and Cathode ray tube are also discussed.

By A. W. KRAMER

triode, the tetrode and the pentode) in Figs. 3, 4 and 5. Secondary emission is the result of impact of high velocity electrons or ions with the atoms and electrons of a solid body such as the plate of an electron tube. The speed with which the impinging electron must strike the metallic surface to get secondary emission depends upon the material and the condition of the surface of the anode. Thus, tungsten with a clean surface requires the speed acquired by an electron falling through 180 volts before another electron is splashed out, but if there is a layer of gas covering the tungsten (adsorbed) secondary electrons may be given off by the impact of an electron falling through only 30 volts. At comparatively low velocities of the impinging electron only one electron may be "splashed" out of the anode but as the velocity increases, more than one may result. In extreme instances as many as a dozen may be splashed out.

In the absence of other influences such secondary electrons will at once re-enter the surface from which they have been emitted, particularly if they are projected into the range of a negative field such as that of a negatively charged control grid. This is shown in Fig. 3. Here an electrostatic field exists between the control grid and the anode as indicated by the (dotted) lines of force.

If however, a positively charged grid such as the screen grid of Fig. 4 is placed between the plate and the control grid, some of the lines of force from the control grid, instead of terminating on the plate, will terminate on the screen grid since that is at positive potential with respect to the control grid. This it will be noted removes (so to speak) some of the lines of force from the space adjacent to the plate. Hence secondary electrons are not driven back to the plate so quickly and if they come too near the screen, they will be attracted to the screen and absorbed in it. Thus, the presence of the screen grid results in an electron current away from the plate.

It is for the purpose of preventing this reverse current that the suppressor grid is introduced. This is illustrated in Fig. 5. The suppressor grid, as has been explained is usually connected directly to the cathode so it is at zero potential with respect to the cathode; it is however at negative potential with respect to the plate, hence a field is set up between the suppressor grid and the plate as shown in Fig. 5. This, in effect, restores the condition present in Fig. 2. It will be seen that the same number of lines of force terminate on the plate as in Fig. 3. It is evident, therefore that in this instance the secondary electrons will also be driven back to the plate. The suppressor grid, however, has little effect upon the high speed electrons travelling from the cathode and accelerated by the control grid and the plate potentials.

In operation and in the method of its use in circuits, therefore, the pentode does not differ materially from the screen grid tetrode. They are applicable as radio

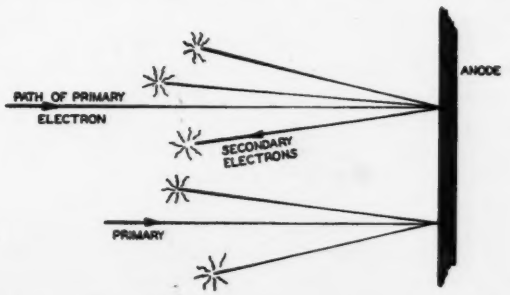


Fig. 2. Diagram showing the principle of secondary emission. High speed primary electrons impinge upon the plate with such force as to dislodge electrons from atoms of the plate material and knock them out into space. Here, 2 primary electrons produce 5 secondary electrons. The number of secondary electrons produced is dependent upon the speed (and therefore the energy) of the primary electrons

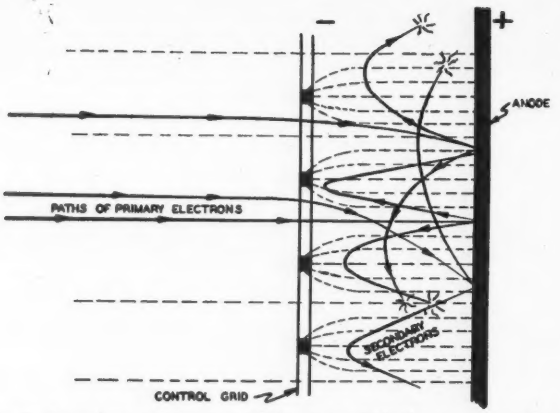


Fig. 3. Secondary emission in a triode. In a triode the secondary electrons are driven back into the plate by the negative charge on the control grid

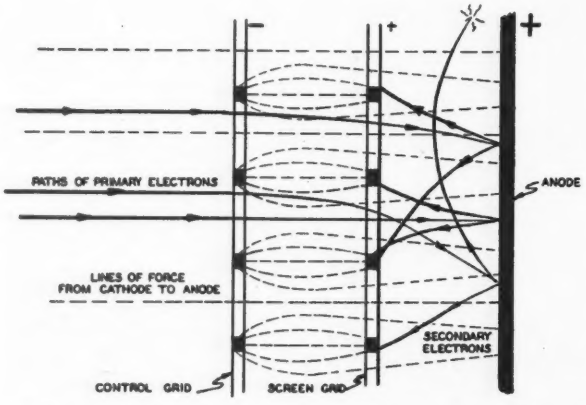


Fig. 4. Secondary emission in a screen grid tube. In the screen grid tube, the positively charged screen grid neutralizes a part of the negative influence of the control grid, thus attracting the secondary electrons originating at the plate

frequency voltage amplifiers and can also be used as audio frequency voltage amplifiers to give high voltage gain per stage. Like the tetrode it has a high amplification factor. They are furthermore suitable as audio frequency power amplifiers. When used as audio (meaning the audible frequencies, 0-10,000 or 15,000 cycles per second) frequency amplifiers, the function of the screen grid is chiefly that of accelerating the electron flow rather than shielding so that when used for this purpose the "screen" grid is often called the accelerator grid.

Typical plate current characteristics for a suppressor grid pentode are shown in Fig. 6. The initial downward slope of the screen grid tube it will be seen has been eliminated and the curves rise smoothly and gradually become flat as the saturation point is reached.

So much for the pentode, at this point at least. It is not our purpose here to enter in too detailed a discussion of these various tubes or to become too deeply involved in a study of their characteristics. Our endeavor here is to indicate how, merely by the addition of various elements, tubes can be designed to have certain characteristics. The addition of the "screen" we have seen, eliminated the undesirable capacity effect of the triode but at the same time introduced a new undesirable effect. The addition of still another element, the suppressor grid eliminated this new undesirable effect and provided a tube with no capacity effect and with high power amplifying qualities.

Insofar as industrial applications are concerned, this is about as far as we need go in tube design. For radio and laboratory purposes tubes with larger numbers of elements are made but these have received little or no application in industry. In many of these several distinct functions are combined into one tube.

Fundamentally, all these tubes are rectifiers and amplifiers, and therefore can also serve as oscillators. Now, of course, it might be questioned why a four or five electrode tube would be used as an oscillator when the screen was introduced specifically to prevent oscillation. The only situation where oscillators with four and five electrode tubes are preferred to oscillators employing the simpler and less expensive triode is where it is desirable to avoid energy transfer between the input and output circuits of the tube through the grid plate tube capacity. Such oscillators can be made more stable and also the highest frequency that can be obtained is higher than in tubes where the capacity effect is present.

With all these developments in tube design, those whom are primarily interested in industrial application need have little concern. We have discussed them briefly here because even a superficial knowledge of their principles and purposes will aid in a better understanding of the simpler types, and also it will make the whole question of electron tubes seem less formidable. With the hundreds of types and sizes of tubes available at the present time and with new developments appearing every day one is likely to feel that the subject of tubes is too complex to give serious consideration.

If, however, it be kept in mind that the multi-element tubes, the tetrodes, the pentodes, hexodes, pentagrid converters, etc., are merely extensions of the triode, the apparent complexity of the subject will largely vanish.

There are other tubes, one in particular, the photoelectric tube, which are used in industry, and which

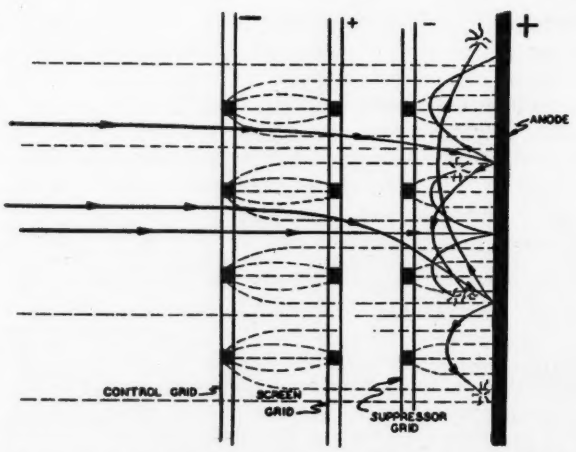


Fig. 5. In the pentode a suppressor grid is introduced between the screen grid and the plate. When this suppressor is connected to a point of zero potential with respect to the cathode, this grid suppresses the influence of the screen grid by re-establishing a negative field close to the plate

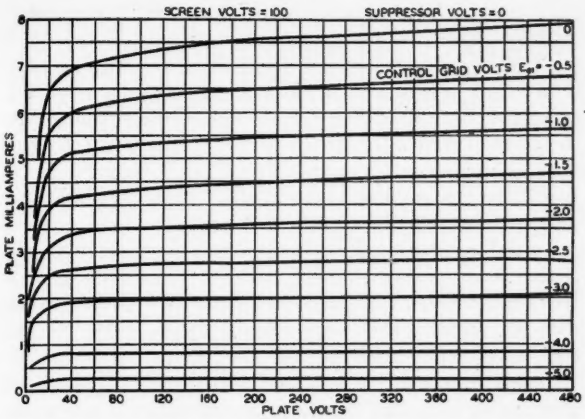


Fig. 6. Suppressor Grid characteristics. The initial downward slope of the screen grid characteristic it will be noticed has been eliminated and the curves rise smoothly and gradually become flat

will be considered later, but these are tubes of a special nature and not part of the thermionic tube family.

The cathode ray tube and the modern X-ray tubes are also tubes of a special nature though these in their present day forms are mostly thermionic tubes. Both of these are used in industry, the former quite generally in combination with rectifier and amplifier tubes.

In the X-ray tube, the electrons emitted by the filament or the cathode are accelerated by an extremely high potential field and deliver the full force of their energy to the anode which is made in the form of a target as shown in Fig. 7. This impact so disturbs the atomic arrangement of the material (usually tungsten) of which the anode is made as to cause it to emit energy in the form of very short wave radiation. This radiation is known as the X-ray.

Thus it is seen, the modern X-ray tube is similar to the ordinary diode insofar as its electrodes are concerned. The electrodes, however, are much farther apart and the potentials applied to the anode are very much higher, usually of the order of hundreds of thousands of volts.

The cathode ray tube used in the cathode ray oscillograph is in some ways similar to the X-ray tube but here, the stream of electrons instead of striking a small anode, impinge upon a chemical coating or deposit on the inside of the end of the tube. The impact of this

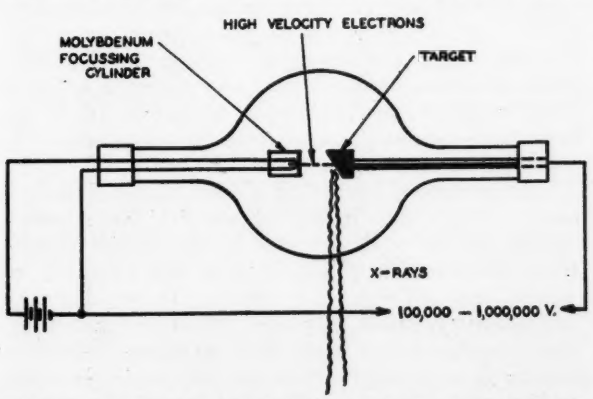


Fig. 7. The modern X-ray tube is simply a diode. Its electrodes are of special design and material and the plate potential is in the order of hundreds of thousands of volts. The impact of the high speed electrons on the anode so disturbs the atomic arrangement of the anode material as to cause it to emit energy in the form of very short wave radiation

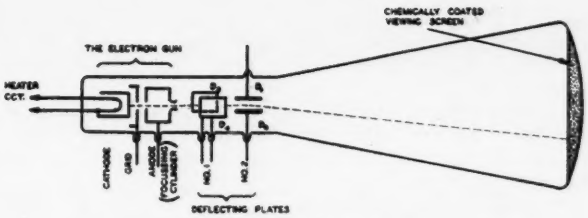


Fig. 8. A typical cathode ray tube, showing the arrangement of the electrodes

electron stream causes fluorescence in the chemical screen which when the stream is narrow manifests itself as a green spot of light at the end of the tube. By means of suitable focusing methods the electrons emitted by the cathode are concentrated in a very thin stream so that only a small spot of light is formed. These electrons, since they carry electric charges, can be attracted or repelled by electric and magnetic fields, hence by arranging electrodes or magnets on either side of the electron stream as shown in Fig. 8, and by applying voltages, or magnetic fields, the electron stream will be deflected, depending upon the voltage applied to the plates. Thus the spot of light at the end of the tube can be made to travel anywhere over the area of the chemical screen at the end of the tube, depending upon the relation and magnitudes of voltages applied to the deflecting plates.

A diagram of a typical cathode ray tube is shown in Fig. 8. The tube has 7 useful electrodes: heater-cathode, control grid, anode assembly and two pairs of deflection plates, Nos. 1 and 2. The assembly of the cathode, grid, and the focusing anode is known as the electron gun. The electrons furnished by the cathode are controlled, accelerated, and focused by the other gun electrodes into a tiny beam, the cathode ray. This beam of electrons strikes the viewing screen which is coated with a chemical compound which fluoresces to produce a brilliant green glow at the impact point of the electron beam.

To obtain a useful pattern or wave form, it is necessary to move the spot horizontally, back and forth across the screen at some convenient frequency and with some suitable motion with respect to time. This produces a horizontal line of narrow width (equal to the diameter of the spot) in the middle of the screen. The horizontal motion or "sweep" is obtained by applying a suitable a.c. potential across the deflection plates D_1 and D_2.

The voltage to be studied is applied across the deflection plates D_3 and D_4 which are placed at right angles to the deflection plates D_1 and D_4. Thus, under the action of the two voltages, the luminous spot is moved not only back and forth but also up and down. This movement produces a tracing of the desired voltage wave under inspection.

This briefly outlines the principle of the cathode ray tube. Its application as an oscillograph or an oscilloscope entails complications that need not be considered here and they in no way affect the operation of the tube. This tube has assumed a position of great importance in the field of measurement and in industry generally and as its cost is brought down through increased usage, it will become increasingly useful in the future.

Self-Regulated Compounded Rectifiers*

This development opens up a new field of power rectifier technique. The principles of self regulation and compounding may be applied to almost any variable. It enters an infinity of control applications.

By

W. Melvin Goodhue

And

R. Burton Power

Harvard University
Cambridge, Mass.

IN THE FIRST part of this discussion[1] a method, or rather, a circuit was described which permits a mercury vapor rectifier to function as its own automatic regulator and also when modified slightly gives the rectifier a wide range of characteristics. The circuits described so far involved only *current* compounding.

Now it will be shown how this same type of circuit may be arranged to provide potential compounding. This makes any variation of the alternating input voltage affect the output voltage in some direct manner. The purpose is to compensate for any failure of the regulator action to neutralize exactly variations in input potential. Also with potential compounding, current compounding may become smooth over a wider range of input potentials. In order to accomplish these various purposes, a potential transformer, Fig. 1, is connected to the 3 phase input. The secondary of the potential transformer operates another pilot rectifier, this time loaded with a potentiometer P instead of a rheostat (as R), because potential rather than current is impressed on the resistance.

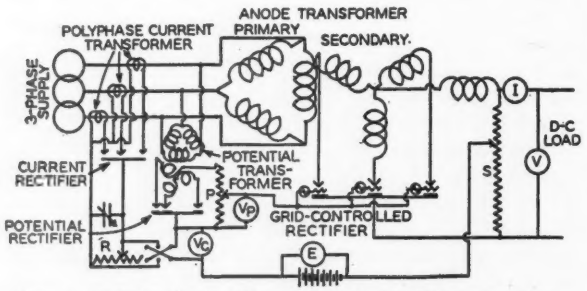


Fig. 1. Rectifier circuit with current and potential compounding

The variable voltage output of this potentiometer is inserted in series with the grid circuit, in a negative direction, opposing firing of the main grids. Thus any increase of the alternating input voltage will be opposed by the grid control. With this connection, it should be remembered that P must carry any positive grid current of the circuit and that the load on the potential pilot rectifier, therefore, is reduced. Hence, if the resistance of P is too high, the current tends to flow backward in the pilot rectifier, which therefore cuts off, making the current zero, and then the potential pilot rectifier does not function. The opposite connection, potential rectifier aiding the grids, is of course possible, but would be needed only if the main output already decreased with increasing input.

The experimental results are shown in Fig. 3 for variation of input and Fig. 4 for variation of load. The input source for Fig. 4 was an unregulated alternator the terminal voltage of which varied widely because of the load variation. Note that the characteristic of Fig. 3 is vertical, showing perfect regulation. In Fig. 4, the curve is flat over a wide range of 3-to-1 variation in load; at very light load the usual rise resulting from ripple and other causes occurs. No capacitor was required in these circuits.

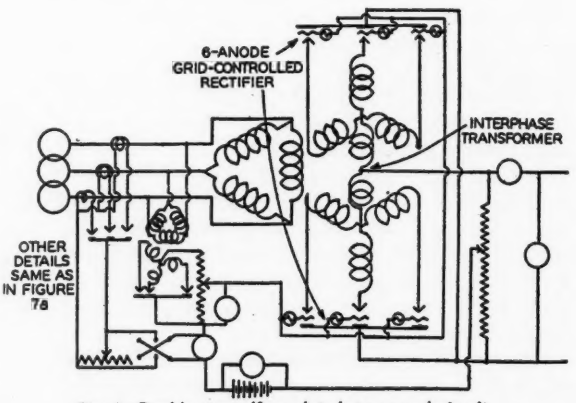


Fig. 2. Double-star self-regulated compound circuit

Potential compounding is necessary only if flat regulation or perfect compensation for input fluctuation is required. For obtaining motor-starting characteristics, rising and drooping volt-ampere characteristics, and other practical purposes, it may be omitted. There might, however, be some application for a rectifier whose output voltage rose on decrease of the input voltage.

The foregoing results have been obtained with 3 anode circuits, and it may be asked if more than 3 anodes can be used. In the double-star interphase-transformer circuit of Fig. 2, each star circuit is an independent self-regulated rectifier. It would not be desirable to regulate only one of 2 or 4 star circuits, since the regulation load range would be halved or quartered, and, because of unbalance, the ripple would be increased. Therefore, 2 or more potential-regulated power circuits in parallel are used. This tends to be unstable, since both potentials are forced to be identical. If the regulators have rising characteristics, the

*An abstract of a paper delivered at the winter meeting of the American Institute of Electrical Engineers, New York, January 25-29.

[1]The first part of this article appeared on page 108 of the February issue.

situation is analogous to 2 compound d.c. generators in parallel without an equalizer bus. In instantaneous action, the firing of an anode in one star circuit tends to prevent (by decreasing grid potential) the firing in the other, one anode of the latter being next in sequence. Also, there is not sufficient time, and hence voltage, for the power impulse to be reliable; this criticism applies also to 6-anode star circuits (not illustrated). The interphase transformer, to the utmost,

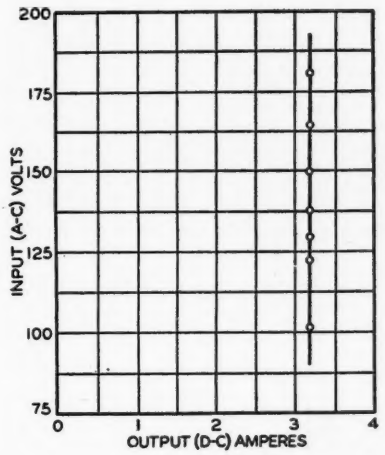


Fig. 3. Constancy of load current during output voltage variations. Characteristics obtained by varying only the field resistance of the input alternator

attempts to force the circuit to operate, and considerable voltage appears on the interphase-transformer.

In spite of these factors, the 6-anode circuit of Fig. 2 has operated in the authors' laboratory. Much research remains to be done in developing a satisfactory multianode technique. One method, now on trial, is the insertion of alternating voltage in the individual grid circuits, using a grid-transformer, and retaining in the common grid return the grid-circuit features of this paper. Time delay, or damping of the grid circuit, also may be necessary.

In conclusion, it may be said that a new field of power-rectifier technique and application has been opened. The principles of self-regulation and compounding may be applied to almost any variable. Self-regulation becomes automatic control and thus

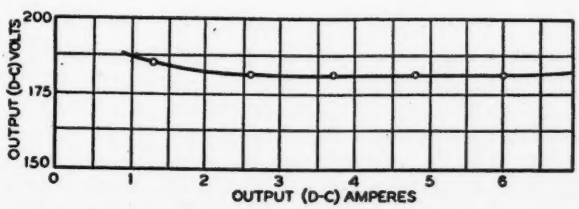


Fig. 4. Characteristics of regulator adjusted for both load and input variation, showing constant-potential output over wide current range

enters an infinity of control applications; the conversion of constant-potential input into constant-current d.c. output, without the use of capacitors or a.c. reactors, may be applied either for power transmission or power utilization. The surface scarcely has been scratched, concerning applications outside the original compound-wound rectifier.

Research in Progress

FOURTEEN universities are coöperating with the Engineering Foundation in an effort to solve technological and human problems in the fields of mechanical, electrical, mining and metallurgical, and civil engineering, according to a report by the Foundation.

Long term projects sponsored by the Foundation include alloys of iron research, comprising a review of world information on alloy steels and alloy cast irons; and welding research, embracing more than sixty fundamental studies in college and industrial laboratories and a compilation of welding literature.

Designs for a new type of critical pressure steam boiler may grow out of a basic investigation at Purdue University by the American Society of Mechanical Engineers. Determinations of viscosity of water and steam, and reactions between steam metal at elevated temperatures have been studied particularly. At the University of Michigan, a boiler feedwater research project is concerned with methods of determining oxygen in the waters.

At the Non-Metallic Minerals Experiment Station of the U. S. Bureau of Mines in New Brunswick, N. J., the problem of embrittlement in boiler steel is being studied with the object of learning its cause and means of prevention.

National Bureau of Standards, Massachusetts Institute of Technology, Cornell University, the Universities of California, Ohio, Oklahoma, and several industries are conducting experiments with long-radius flow nozzles, used in fluid meters, in order to provide more economical and convenient means for precise measurements of large quantities of liquids or gases, as in efficiency tests of steam and hydraulic power installations. In some instances steam is used, in others water, through nozzles ranging from 3 to 16 in. in diameter, and also through two-inch pipe orifices.

Ten years of research on pure iron electrodes, sponsored by the American Institute of Electrical Engineers at Lehigh University, was recently completed. This phase of welding research will be merged in the comprehensive program of the Foundation's welding research committee.

Information on the creep and relaxation of metals was gathered last year as part of a study of metal plasticity carried on at the University of Pittsburgh with research facilities provided by the Westinghouse Research Laboratories. Special apparatuses were designed and constructed for the work, the results of which are proving of practical value.

Nearly 500 specimens of concrete are under observation in long-time tests at the University of California to determine the various factors in the plastic behavior of concrete. Three new series of investigations have been started, comprising studies of the moisture loss accompanying plastic flow under sustained load; of the validity of the assumption of plane bending in beams under sustained load; and of the effect of compound composition and fineness of cement upon plastic flow. Thermal stress studies have already been completed.

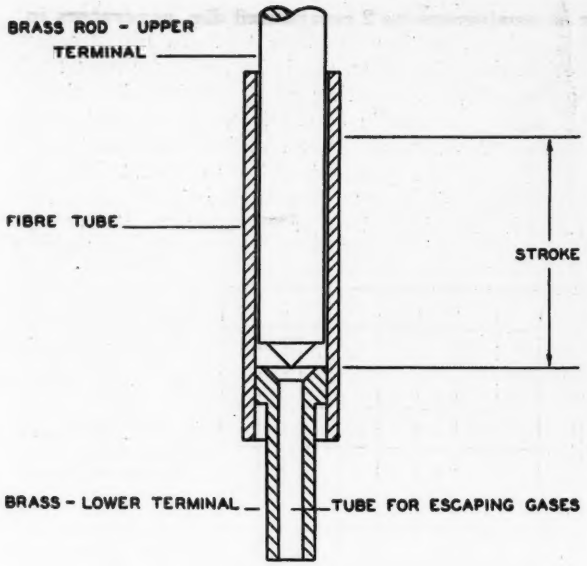


Fig. 1. Diagram showing principle of the expulsion tube circuit breaker

A New Type of Circuit Breaker

By FRANK A. EASTOM

Assoc. Prof. Electrical Engineering, Univ. of Colorado

THE ADOPTION of large electric generating plants and the interconnection of extensive networks has given rise to a need for circuit breakers of extremely high interrupting capacities. System stability limitations also demand that short circuits on a system be cleared in 2 to 4 cycles with a minimum arcing period between the contacts within the breaker. Operating voltages have in some cases reached almost 300,000 v. and the combination of these circumstances has led to the design of oil circuit breakers of very large dimensions. These conditions have naturally provided the incentive to create new types of breakers employing little or no oil for extinguishing the arc, and in which the proper insulation is supplied by the use of porcelain insulators and air. Accordingly, within the last six years several new types of breakers have appeared on the market, in which the amount of oil necessary for successful operation has been either materially reduced or eliminated altogether.

The Arc Rupturing Process

A consideration of the circuit breaker problem would be quite incomplete without an understanding of the electric arc and the arc rupturing process. Briefly, this process is as follows:

In order to maintain an electric arc there must be a high temperature at the cathode at which the emission of electrons is produced. In a circuit breaker the temperature of the cathode is raised as the contacts separate due to the high current intensity and the electrons which are emitted strike the gas molecules between the contacts and ionize them. Thus the electrons stream through the ionized gas and form the electric arc between the breaker contacts. When the alternating current passes through zero, the arc is interrupted. Immediately the gap begins to deionize due to the recombination of the positive and negative ions and also partly due to the fact that the cathode will absorb some of the positive ions in its immediate vicinity. When deionization has been completed the gap will recover its dielectric properties and become an insulator which cannot conduct an electric current unless a high voltage is placed across the gap which will be sufficient to re-ignite the arc. When an alternating current breaker opens therefore, the arc is extinguished at the first current zero, but the dielectric properties of the gap are restored so slowly that the high peak of the recovery voltage which appears between the breaker contacts is certain to reignite the arc unless the deionization of the gap is accelerated in some manner. Fortunately this can be accomplished in a number of different ways. Thus oil may be forced rapidly into the arc space when the contacts separate.[1] This forces the ionized gas out of the gap when current passes through zero and substitutes in its place a material of high dielectric strength which the recovery voltage cannot puncture. The above condition can also be fulfilled by means of compressed air which may be

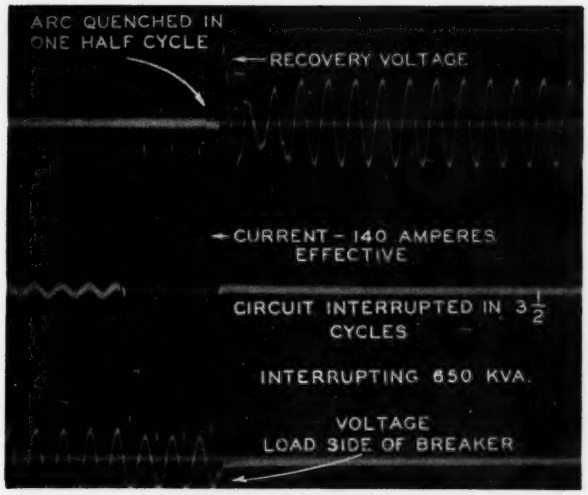


Fig. 2. An interruption at 650 kv-a. in which the arc was quenched in ½ cycle, and completed in 3 cycles

used to displace the ionized gas in the arc space.[2] It has also been found that steam will accelerate deionization of an arc space.[3]

We may now reiterate, that in order for a breaker to properly interrupt a circuit, the recovery of insulation strength between the contacts must exceed the rate at which the recovery voltage rises and if this does not occur the arc will be re-established.[4] The rate of rise of the recovery voltage, together with the maximum peak value of this voltage may be very high. Recovery rates depend upon the constants of the circuit to be interrupted and may in some cases reach a value of 1500 v. per micro second.

Details of New Breaker

Stated in a simple way, the objective in circuit breaker design is the rapid removal at high velocity of the ionized gas between the contacts and the immediate introduction of a non-ionized gas, oil, or other insulating material which will take its place. In accordance with these principles a circuit breaker has been constructed in the Electrical Engineering Laboratories at the University of Colorado, the design of which is very simple and, it is believed, new and unique. It has been called by the name "Expulsion tube breaker" for the reason that it operates in a manner somewhat similar to that of the old expulsion fuse, with which engineers have long been familiar. The breaker is built up on a pipe frame and consists only of brass rods, porcelain insulators and fibre tubing. The laboratory model is built for operation on 2300 v. 3 phase circuits and is constructed in the following manner: Referring to Fig. 1 which represents one pole of this breaker it is seen that the upper and lower contacts are of brass. The upper contact is movable and slides up and down within a fibre tube. However, the stroke is only 5½ in. and the contact never leaves the upper end of the tube which therefore remains fairly air tight. Also, within the fibre tube but at its lower extremity is situated the bottom contact which consists of a brass tube 6 in. long with a ¼-in. bore. It is through this hollow brass tube that the ionized gasses are vigorously expelled. The upper contact is tapered at its lower end which fits into a recess in the lower stationary contact when the breaker is closed. As the breaker opens, the arc is drawn between the contacts within the fibre tube and the gasses generated by the heat of the arc are forced out through the hollow tube which forms the lower contact. It is seen that this breaker is far from being complicated. It uses no oil or water, and needs no outside source of compressed air or gas. The parts are easily assembled. The tripping device is actuated by means of a small electromagnet through the contacts of a relay which is energized from a current transformer in the usual manner.

Performance

The performance of the laboratory model of this breaker has been quite satisfactory. It has interrupted 650 kv-a. at 2300 v. hundreds of times in 3 to 4 cycles while the arc between the electrodes has been quenched within one-half to one cycle. Fig. 2, taken on a galvanometer type oscillograph depicts an interruption at 650 kv-a. in which the arc was quenched in one-half cycle, while the interruption was completed in 3½ cycles. The peak value of the recovery voltage was 3420, which was reached .003 sec. after the arc was extinguished. The breaker has repeatedly interrupted dead short circuits of over 4000 kv-a. in 3 cycles, while the arc was extinguished in one-half cycle, as shown in Fig. 3, in which the peak value of the recovery voltage was calibrated at 3800, which value was reached .0013 sec. after the arc was extinguished. The complete breaker ready for operation is shown in Fig. 4.

Theory of Operation

The theory of arc extinction in this breaker is perhaps dependent upon several factors as follows:

1. It is remembered that when the current passes through zero, the arc between the contacts is interrupted and the gap immediately begins to deionize due to the cathode absorption and the recombining of the positive and negative ions. But this process is too slow and must in some way be accelerated.

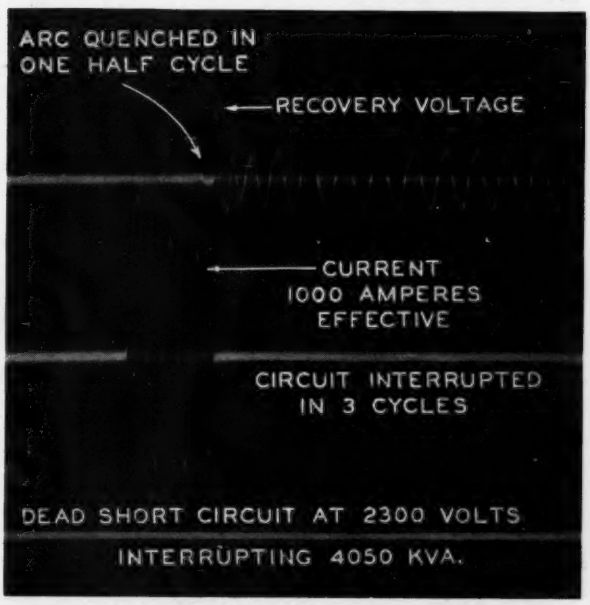


Fig. 3. Quenching a short circuit at 2300 v. in a ½ cycle

2. It is well known that a fairly effective means of increasing the rate of deionization is to force an arc close to some insulating material upon which the ions may collect and recombine. Arc chutes are often used for this purpose and they are effective in restoring the dielectric properties of a gap.

3. The tremendous heat of the arc burns or decomposes the inside walls of the fibre arcing chamber and in this way a large quantity of non-ionized gas at high pressure is produced.[5] At current zero, this pressure forces the ionized gas down the tube at high velocity and out into space through the lower hollow terminal. The space between the contacts is now composed of non-ionized gas of high dielectric strength which the recovery voltage is unable to puncture. In other words, the ionized gas has been removed from its position between the contacts and that space is then filled with a non-ionized gas. It is evident that the displacement of the ionized gas with non-ionized gas must take place in a very short period of time measured in micro seconds.

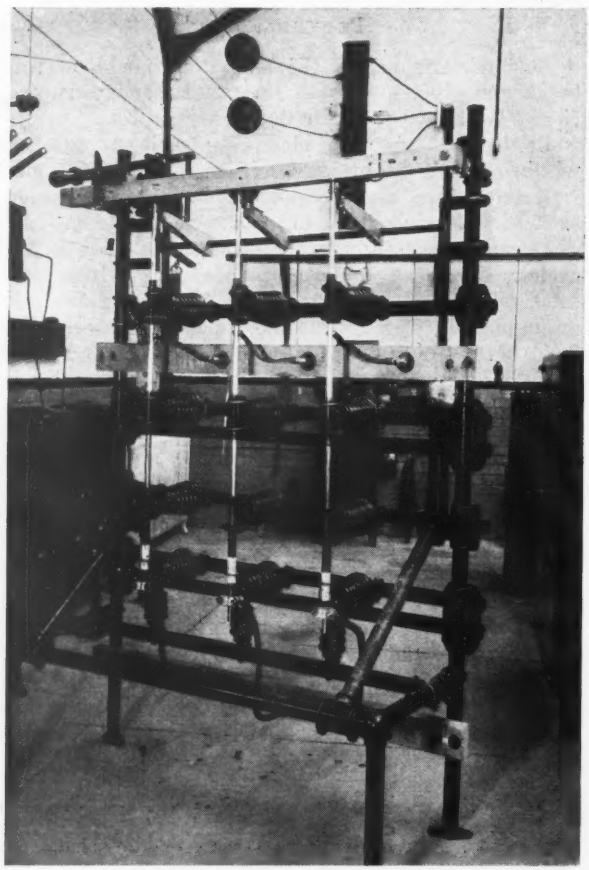


Fig. 4. View of the breaker, ready for operation

It is certain that item number 3, above, is one of the important factors involved. After the breaker had opened approximately 100 short circuits it was taken apart and examined. The inside of the fibre arcing chamber was slightly burned in a few spots forming small rings, but there was no evidence of bad burning and very little carbon was formed. Heavy pyrex glass tubes were then substituted for the fibre tubes. A decrease in efficiency was at once apparent, as 8 cycles were consumed in interrupting a load of 650 kv-a. and 8 half cycles lapsed before the arc was quenched. It is, therefore, concluded that the decomposition or burning of the inner walls of the fibre arcing tubes produces the non-ionized gas which is instrumental in preventing re-ignition of the arc after current zero.

This breaker is therefore a gas blast device and the fibre arcing chambers will eventually have to be replaced. This is a simple procedure, however, and it is believed that a set of tubes would last 3 or 4 yr. in ordinary operation on feeder circuits. It would be unwise at this stage to claim that this model breaker has solved any one of the multitude of problems involved in circuit breaker development. However, it works, it is easy and economical to build, and the absence of oil simplifies its maintenance.

REFERENCES

1. D. C. Prince, Electrical Engineering, Vol. 54, No. 4, page 366.
2. J. Biermans, A.E.G. Progress, Vol. 5, No. 9, page 279.
3. F. Kesselring, Siemens Review, Vol. 6, No. 9, page 207.
4. E. W. Boehne, Electrical Engineering, Vol. 54, No. 5, page 530.
5. Slepian and Denault, Transactions A.I.E.E., March, 1932, page 158.

What a Steam Trap Can Do—

SIMPLE AND unobtrusive as a steam trap appears, it may be a large factor in reducing power and process costs. Of course proper application and installation are essential to securing the best results. Some instances given in the Armstrong Trap Magazine are as follows: Elliot Packing Co. at Duluth, by putting a trap on each cooking kettle reduced cooking time from 8 hr. to 3½ hr., thus increasing capacity over double. Also by hooking a trap to the oil separator in the gas line from compressor to condenser of the refrigerating plant. discharging this into the oil separator on the gas line from evaporator to compressor, heating that separator with a steam coil whose condensate was removed by a trap, and drawing off the oil from the second separator by means of a third trap, the oil was so well eliminated from the refrigerating system that effectiveness was greatly improved.

In the Grand Laundry in Chicago, some rolls of a flat work ironer were sluggish and did not heat up enough to do satisfactory work so that the ironing had to be done over. By putting a trap on each of the six rolls, all were held at the same temperature, reironing was eliminated, roll covers were kept free of rust stains, output of the rolls was increased about one third.

In the plant of Becker Cleaners, Chicago, back pressure in the tank which receives condensate from presses and other equipment was 45 lb. and trap operation was slow. By running 30 ft. of ½-in. pipe from the top of the tank to a point well below the bottom and connecting this line to a trap with air by-pass, the standard air vent being closed and the air by-pass adjusted to close well below steam temperature, the air was eliminated from the system. The air is discharged about every 45 min. and back pressure has been reduced to 25 lb.

It is worth while to consider where and how traps may be used to effect similar savings.

GRAND RAPIDS
Stamping Division of General Motors Corp.

RECENTLY, at Grand Rapids, Mich., the new Grand Rapids Stamping Division Plant of General Motors Corp., was put into service. It is operated by Fisher Body Corp. and incorporates all features of modern industrial plant layout which has been developed so highly in the automobile industry. Compressed air and steam are supplied from a new power plant of modern design harmonizing with the general architectural treatment of the plant and set off by a steel stack with alternate bands of bright yellow and black which makes it a Grand Rapids landmark.

Electric power is purchased from the local utility company and supplied by a separate 7200-v. line to the plant. This line is connected to the switch house bus bars through a bank of oil switches. The buses feed, through other oil switches, seven primary circuits. From these 7200-v. primary circuits power is distributed to five transformer vaults at various sections of the plant for 240-v. distribution.

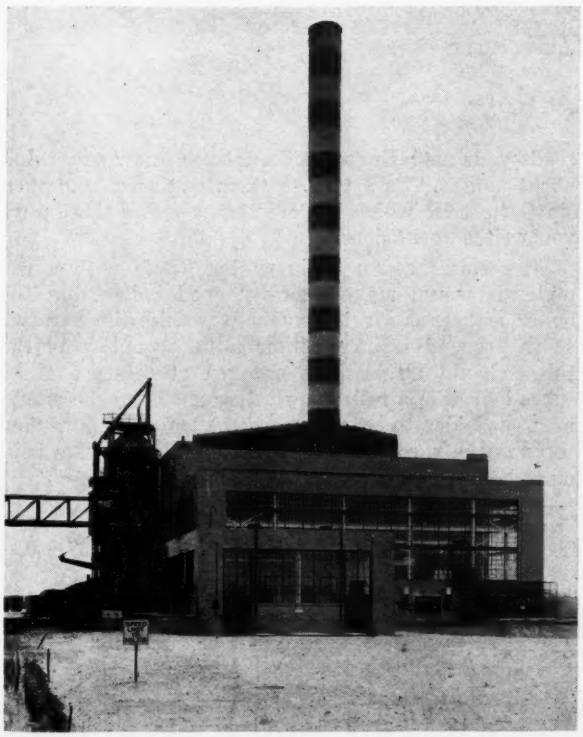


Fig. 2. Exterior of power plant. The boiler room has three 600 hp., 200 lb. boilers with space provided for the fourth one

Power factor correction from a minimum of 96 per cent to 100 per cent, depending upon the load, is provided by the installation of 15 banks of 100 kv.-a. capacitors. The switch house is a separate structure, unique in that three walls consist of translucent glass brick used primarily for its heat insulating properties. This glass wall provides much greater insulating qualities than a 12 in. wall of ordinary brick, and, for this reason, the ordinary brick is used for structural purposes only.

Humidity control in the switch house is provided by automatic regulation of the room temperature in accordance with the dew point of the atmospheric air. The humidity is controlled, not by removal of moisture, but by varying the temperature.

The power plant has three 600-v. hp. water tube boilers, designed for a maximum of 200 lb. pressure but operated at 150 lb. These boilers are fired by underfeed stokers and are provided with combustion control, CO_2 meters, draft gages, steam flow meters and

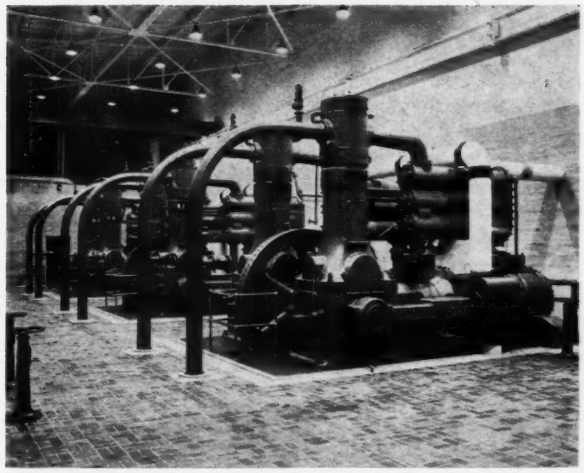


Fig. 1. High pressure steam is used to drive this battery of 3300 c.f.m., 100 lb. angle compound air compressors

steam purifiers. Boiler settings have air cooled side walls, air entering at the bottom and leaving at the top through ducts which lead to the steam turbines, driven by forced draft fans in the basement.

At present a West Virginia slack and nut mixture is being burned. Hopper bottom cars dump to a track hopper from which the coal is elevated through a cylindrical bunker by means of a skip hoist for distribution to the stoker hoppers by means of a larry. Boiler ash pits dump directly to industrial cars and these in turn discharge to a skip hoist which elevates them to a cylindrical ash bunker for delivery to railroad cars or trucks.

In the compressor room, which is divided from the boiler room by a curtain wall, there are three banks of duplex, two stage, 100 lb. air compressors, each unit with a capacity of 3300 c.f.m. These compressors are of the steam driven angle compound type.

Boiler feed and other water is obtained chiefly from a well but there is an emergency city water connection. With the exception of the boiler feed pumps, located in an auxiliary bay on the firing floor between the boilers, all pumps are located in the basement. One of the important services performed by these pumps is the circulation of cooling water to the welding machines, after which it is cooled in a spray pond located in front of the power plant at the right of Fig. 2.

For the guidance of the chief engineer, the office is equipped with a control panel with recording flow meters for each boiler, air from the compressor department, 5 lb. steam to the plant heating system from the compressor exhaust, and, high pressure steam makeup to the reducing valve. In addition to the flow meter, the outside air temperature, compressed air pressure and high and low steam pressures are shown. In the switch house is a combination meter which records the total power input and the power factor.

Fig. 3. The switch house is built as a separate building with glass brick on three sides

We brought this on ourselves; nobody else is to blame. This is the result of one man's reaction to our article "How to write an Article for Power Plant Engineering." How do you like it? We think it "swell."

Principles Underlying Furnace and Heat Trap Design

By PULVERIZER PETE

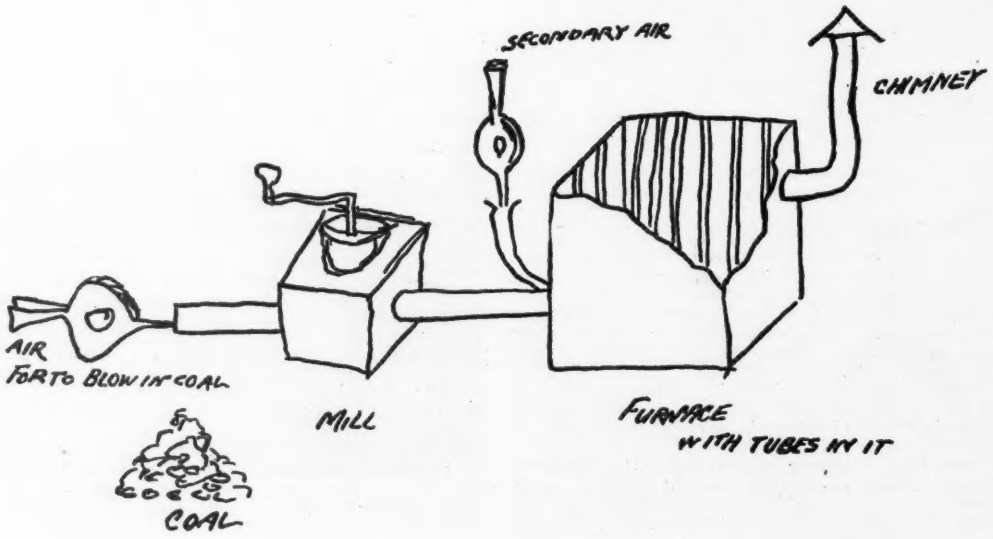
IT'S YOUR OWN FAULT, EDITOR, that I gets this idea; because if you hadn't wrote your article on how to write an article I probably wouldn't never have thought to tell you about furnaces and boilers.

In the first place I wants to tell you I ain't got no edjication; but you says grammar don't count and anyway I gets lots of practical experience sweepin' up in a power plant.

What starts this whole business is when the company buys a new boiler and pretty quick a lot of engineers comes round with a mess of drawings and tangled up pipes, which they says is going to be a Stirling boiler. I couldn't find no sterling except the contacts on one of the controls. So I looks at them drawings and right away decides that the fellers what reads your magazine should ought to know something about boilers. So I talk to them engineers and then starts to write which is more than some of those guys you writes about does.[1]

It seems that an ordinary tea kettle with a fire under it would make a pretty good boiler; but the boiler makers is afraid somebody would discover this so they spends all their time tellin' people why the tubes should all be bent crooked et cetery. These tubes look like a railroad yard which it maybe would be a good idea to copy because the trains seem to flow through the yard better than the circulation what is in most boilers.

[1]You said it, Pete. (Ed.)

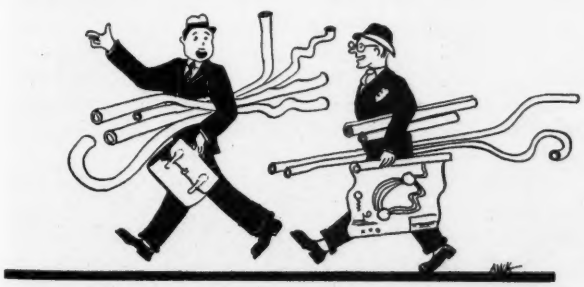


It's your own fault, Editor, that I gets this idea

The first thing you does is builds a furnace and puts a hell of a big fire in it. Then you finds that you can't hire enough men to shovel the coal in and the ash out fast enough so you grinds up the coal in a coffee mill and blows it in. (The coal not the mill.) This makes it burn better and the ash blows out the chimney, which makes everybody except maybe the neighbors happy. You also blows in secondary air which I can't see why they calls it secondary because it looks like any other air.

Now that you has a good big fire you makes the furnace smaller to make it layed out more effishently. Then it gets too hot so you sticks a lot of tubes full of water around the inside. This makes it look like a cage at the zoo and probably it's too cold so you smears a lot of refractory over the tubes. If this makes it too hot again you can stick a lot of studs or cold nails through the refractory on to the tubes, but maybe it is much more better to start over again with a bigger furnace.

I forgets to tell you where to get the water to put in the tubes which in truth comes from the boiler so maybe you should put the boiler right in the furnace where it is nice and handy.



A lot of engineers comes 'round with a mess of drawings and tangled up pipes which they say is going to be a boiler.

Seein' as how I aint got no camera I am drawin' a picture of how your job should look which, Ed, you says you will fix up and decorate. (I mean the picture.)[2]

Now you has to pick out a boiler which can have either straight or bent tubes. The bent tube ones is probably cheaper because the tube factorys couldn't sell their crooked tubes to anybody but a boiler maker.

In a boiler you got to make the steam hot while the tubes they don't get too hot and you has to make the water come down and the steam go up which it is best not to have happen in the same tube. So if you likes the way I wrote an article how you showed me I will tell you more about boilers next month.

[2]We didn't have the heart to do it. (Ed.)

Electricity Output in 1936 is 14 per cent greater than in 1935

PRELIMINARY FIGURES on the total production of electricity for public use in the United States in 1936 indicates a total output of 113,473,000,000 kw-hr., which is an increase of 14 per cent over that for 1935, the year of the previous maximum.

The production of electricity by the use of water power was about 40,893,000,000 kw-hr., or 2 per cent more than in 1935, and amounted to 36 per cent of the total, whereas the average for the 16-year period, 1920 to 1935, was 36.9 per cent of the total. The percentage for 1936 indicates that despite the abnormal conditions experienced in the drought stricken states the production of electricity by the use of water power is maintaining its relative position with respect to other sources of power.

The preliminary data indicates that the fuel rate for 1936 will be about 1.45 lb. per kw-hr. as compared with 1.46 lb. per kw-hr in 1935. Following the former procedure of the U. S. Geological Survey, the fuel rate was calculated by converting the oil and gas used in the production of electricity into equivalent tons of coal and dividing the total coal used in producing electricity and coal equivalent of the gas and oil used by the corresponding output. This method does not allow for the variation in B.t.u. content of the gas and oil as fired, and includes the output of both steam and internal combustion engines, and is therefore only approximate.

An analysis of all steam plants using coal exclusively for fuel indicates that the coal rate is 1.49 lb. per kw-hr. Since these data include coal used in plants held in reserve and operated intermittently, it is not representative of good practice. Some of the more efficient plants are producing a kilowatthour with approximately .8 of a pound of coal at the present time.

Tables in the report show for the United States and its divisions the annual production of electricity for public use by use of water power and by the use of fuels for the years of 1935 and 1936 and the percentage change from 1935 to 1936 in the production of electricity and in the use of different fuels in generating electricity.

Copies of the report may be obtained by application to the Federal Power Commission, Washington, D. C.

Pulverized Fuel Presents Operating Problems

By MARK BELL

MUCH has been written about pulverized fuel from a technical standpoint but, once it has been installed, it is the practical burning and operation which, more directly, affect most of us. It is of paramount importance to ascertain the exact range of steam output during the whole year. If, during some periods, the load drops to 10,000 or 12,000 lb. per hr. whilst, at others the load borders on 100,000, many headaches will be avoided if two burners are installed for the boiler. Practical men will agree that the adequate range for a single burner from top to bottom load should never be more than 5 to 1. Although the installation of one burner will be cheaper and slightly simpler than two, if the load varies more than 5 to 1, two should always be fitted. The whole success of pulverized fuel burning depends upon the correct intermingling of the air and fuel and their injection into the furnace at sufficient density to ensure combustion. Although this is an obvious statement, its implications are often slurred over, with poor results. An added advantage is the fact that the flexibility is greater, the use of oil for pilot flame is diminished and the whole plant kept cleaner, as one blowout will cover the whole boiler house with a fine dust which requires washing away with a hose.

The plants which, after experimentation with pulverized fuel, revert to oil fuel show us that there is only a narrow margin in favor of pulverized fuel in many cases and, unless the service can be maintained trouble free and cleaning and maintenance kept down, the margin will grow even less.

Holding the Fire

When only one burner is installed and the load range is great, several things will help to keep the fire continuously lit without too great use of the oil torch. The mill should be kept in the best condition so that very fine pulverization may be had at all times. At very low loads the air supply, both primary and secondary, should be curtailed as much as possible. Only enough primary air to sweep the mill should be used as the consequent discharge will be richer and ignition on leaving the burner tube assured. If the burner be of the turbulent type, the vanes should be set to give the best possible mixture even if the flow is slowed up somewhat but, if this is done, the burner must be watched closely for coking and consequent burning of the rosette. With some mills it is possible to deflect some of the discharge back into the suction side of the mill. This will decrease the flow but is not really good practice as it necessitates work being done over again. The secondary air should also be cut down as far as possible whilst allowing enough to give full combustion without cooling off the furnace. Obviously, the hotter the furnace the better the ignition of the particles, and curtailing the primary and secondary air will keep the temperature up. There is a danger of flarebacks if the flow is cut down too much but it is not sufficiently great to be taken into much account. Some operators get the slowing up effect by throttling the coal cock below the burner, but this practice is not to be advised as there is a danger of plugging the mill.

Operators must never lose sight of the fact that pulverized coal is a highly explosive substance and care must be used in dealing with it. Also, if the explosion doors are not vented to the outside and, due to loss of fire, they open, it is almost unbelievable how filthy they will make the whole boiler room with one puff. A fine film of soot, unconsumed particles of coal and dust will cover the whole place and this mixture may find its way into bearings and instruments with deleterious results. At low ratings it is good policy to have the oil burner continuously lit. Whilst this may use 700 or 800 gal. a day, the expense is justified as it practically ensures continuous operation and the B.t.u.'s of the oil are not wasted as they go directly into the furnace. Always, also have a bucket of kerosene handy with a torch immersed in it. A box of matches must always be handy. It is a fine idea to have a piece of 6-in. pipe about 3 ft. long and blanked off at one end standing beside the boiler. This can be half filled with kerosene and an ordinary torch immersed therein. It is handy to light and put in the furnace if needed and, when taken out, can be plunged, still alight, into the tube where it will be extinguished.

Take Time to Relight

When and if the fire does go out, take your time about relighting. Stop the feed of coal to the pulverizer, speed up the forced draft fan and open the damper wide. The steam pressure will drop somewhat, but let it. Give the furnace a couple of minutes to clear itself and then, and only then, ignite the oil torch and put it in. Even with these precautions there will be somewhat of a flareback and the explosion doors will open slightly. Unless their opening is reduced to a minimum, however, cleaning up will take hours. When the fire is lit, place the coal feeder again in service and regulate the fan and damper. It will take only a minute or so for the steam pressure to get back on the line. Then ascertain the reason of the loss of fire and remedy it.

Here a word may be said about the quality of the coal. It is one of the claimed advantages of pulverized fuel that a very low grade of coal may be used. This is so, but one must bear in mind that, should the coal contain much noncombustible matter, the wear on the pulverizer parts and the cost of removing the extra deposit on the tubes and in the ashpits will offset the initial saving. Great importance should be attached to keeping the coal dry at all stages. If wet it hangs up in the bunkers and shoots and, in some types of installations, clogs the dust screens. The moisture should be not more than 4 per cent.

If the fineness after pulverizing tends to get less (at least 80 per cent should pass through a 200 mesh screen and 90 per cent through a 100 mesh screen) the pulverizer should be overhauled and this should be done without delay. Bad pulverization means large particles with consequent poor ignition, increased slag forming and increased waste of unburned coal mixed with the ash.

REFRIGERATION System Control

Selection of equipment depends upon the type of plant and service demands

By W. R. Kitzmiller

AFTER ARRIVING at the cooler and condenser sizes* for a given refrigeration machine* the question arises as to the type of control to select. The manually operated plant requires few automatic controls and most of these are subject to periodical examinations. In every plant there are, however, controls which of necessity should be strictly automatic. These should be selected with great care, especially so if the plant is to operate without supervision. The control problem will be considered in relation to three types of plants, namely: manually operated, semi-automatic and automatic.

At first glance the manually operated plant should have few control problems, but after considering the problem thoughtfully it will be discovered there are many improvements in controls available to permit the operator more time for other duties. In many plants he has the actual supervision of everything around the place except the office clerical work or bookkeeping. In some cases he is actually responsible for an accurate cost accounting, the heart of the business profits.

*Capacity calculations for refrigeration compressors and for condensers and coolers were discussed by the same author in Power Plant Engineering on page 681 December, 1935, and page 600 of the October, 1936, issue respectively.

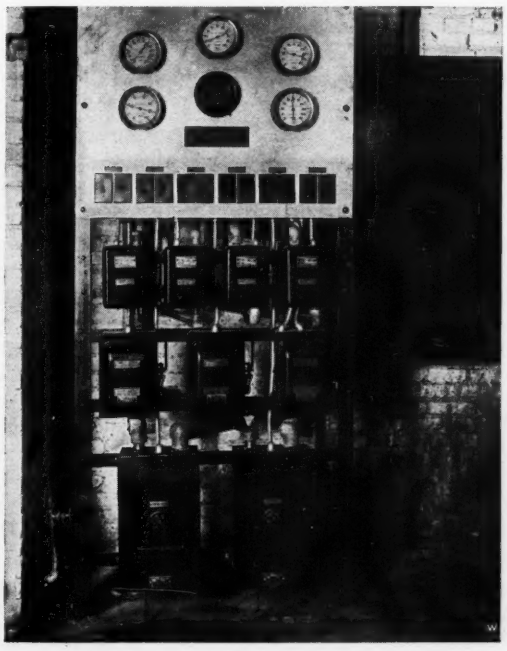


Fig. 1. Typical control panel of a small well designed plant

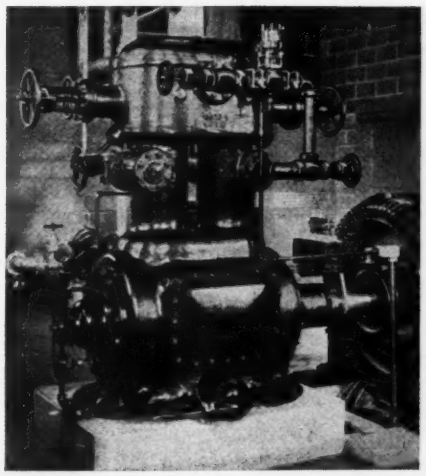


Fig. 2. Refrigeration compressor equipped with an automatic unloader. The solenoid valve opens to equalize pressure when the machine is started and automatically returns to normal when the machine is up to speed

With the advent of the community "Locker System" of storaging individual's food products, many operators have additional duties.

Wherever possible the evaporators can be flooded from float valves or electric valves to remove the question of proper ammonia feed. As a general rule this involves only the larger coolers around the plant, leaving many smaller room controls, especially where the "Locker System" rooms are added to existing plants as is now common. The proper way to handle these types of rooms is to employ a thermostat and electric valve and control the ammonia feed automatically according to room temperature as shown in Fig. 3. This can be done if the equipment is connected to the main plant or a separate machine. In cases of small machines the control can operate both the valves and machines.

The compressor should be complete with its automatic lubricating system and, where dangerously high condensing pressures sometimes exist accidentally, a high pressure cutout. This pertains primarily to the electric driven machine, although proper controls are available for gas or oil engine drives. Another and to the operator is the unloader which permits him to start up the compressor by simply "pressing the button," so to speak. The pressures are equalized during starting and automatically returned to normal when the machine reaches speed. The unloader is shown in Fig. 2 and proves of special benefit where plants are subjected to severe electrical storms which normally cause

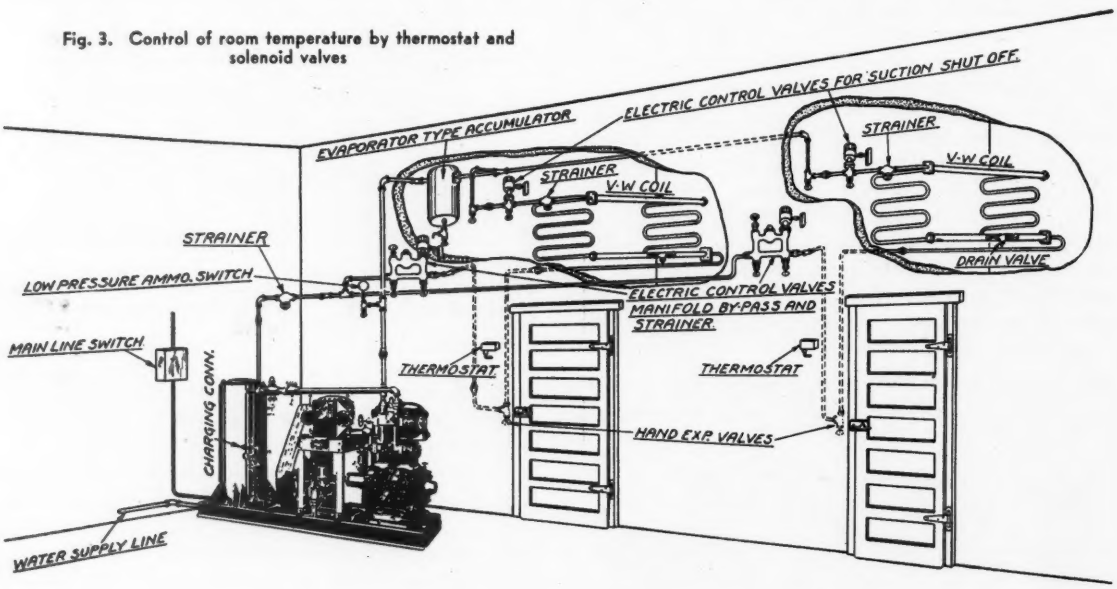
frequent shut-downs. The unloader will frequently "carry over" minor electrical disturbances and in any event permit a quick restart. It is also possible to employ low torque motors for service where higher torque might be required.

Semi-Automatic

Semi-automatic plants probably prove the most interesting of all control problems. The average engineer often loses sight of many duties around the plant which could be done without his presence or assistance, at the same time insuring proper temperatures, even better regulation. This generally applies to "stored" refrigeration which can be shut down at the proper time thermostatically or by time clock. The same thing is true in starting up, as is often the case in dairies requiring a quantity of cold brine when they arrive in the morning.

There are many duties around a plant of this type through the day but not at night. Minor operations

Fig. 3. Control of room temperature by thermostat and solenoid valves



can, therefore, be taken care of at night, with proper controls, without an operator. This is true primarily of a large refrigeration system employing many compressors, throughout the day, manually controlled. They have a variety of duties to perform after which they are hooked up to a large brine tank. A thermostat shuts off a relay, connected into the "stop" side of the push-button station of each starter, when the brine has been lowered to the proper temperature that night.

Machines cannot restart, so an electric valve closes off the ammonia supply and the plant awaits the operator next day. From this tank of cold brine small pumps, thermostatically controlled from room temperature, circulate brine as required to maintain the proper room cooling until morning. The brine tank next day helps to remove the peak load from the refrigerating machinery and the operator carefully regulates his direct expansion loads to meet requirements.

Many plants are troubled with "slopover" ammonia at different times. Fig. 4 illustrates an automatic arrangement which separates the entrained liquid and returns it back into the system automatically. This arrangement requires little power but saves considerable in eliminating slopover on the compressors. The float switch is actuated by the amount of slopover and the electric valve in the main liquid line reduces the chances of recurrence in a short time since it remains closed during the return cycle. The setting of expansion valves need not be so closely regulated.

Automatic Control

It might seem that some of these descriptions verge on the automatic plant and each piece of automatic equipment mentioned, such as unloader, floats for flooded control and electric valves with thermostats for room control does have its place in the strictly automatic plant. In addition to these items, however, the proper arrangement must be used in order to secure the best results and there are additional items, such as automatic motor starters for the compressors, pressure limiting switches for safety, and refrigerant control and condensing water valves necessary to secure complete automatic operation.

Figure 5 illustrates the electrical connections for a typical multiple room system which involves several unusual complications. The control of one box and compressor, similar to the household machine, is a rather simple installation. When many rooms are to be controlled various problems come up, since different sizes and temperatures will be involved. The diagram illustrates the simplest form of these arrangements since the thermostats open and close the liquid electric control valves according to temperature. The pressure switch in the suction line prevents an excessive feed of ammonia. When the suction pressure is normal the room cooling continues. As will be noted, the machine starts from any thermostat and operates until all are satisfied.

As the control problem becomes more complicated

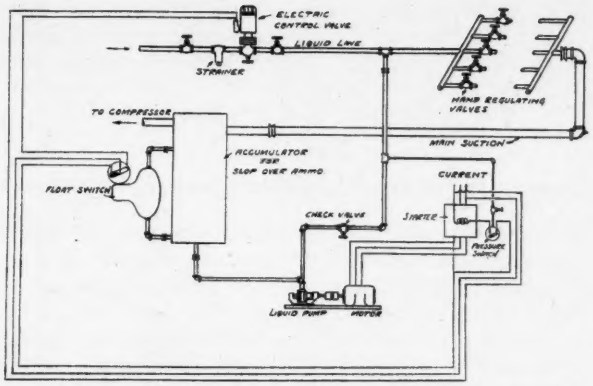


Fig. 4. This arrangement to take care of ammonia slopover automatically eliminates the need for such close regulation of the expansion valve. Cold liquid is returned to the low side with a small amount of power

with a variety of temperatures for different rooms the electric control valves are also used in the suction lines. This permits a room to be sealed away from the rest of the system as soon as the thermostat is off. The general arrangement is practically the same as in Fig. 5 except that two valves are opened. The piping arrangements are similar to Fig. 3. The pressure switch still controls the liquid valves but the suction valves operate independently.

Where freezer rooms are included with high temperature rooms it is necessary to cool the high temperature rooms first and then the full machine capacity is devoted to the freezer. Heat exchangers in the suction line are essential on most jobs to eliminate slopover during variable load conditions or seasonal changes. Additional pressure control is also involved on many systems employing freezing conditions with high temperatures. The booster compressor for very low temperature work can be automatically hooked up with the high temperature machine.

It is often impossible to proportion the loading between compressors because of variable conditions, but on large systems several machines should be used, or, a machine fitted with capacity control. This will permit better regulation and more economy. Two compressors are of considerable advantage since they can be arranged so if one does not carry load the other comes on and helps out. Furthermore, a break down in one machine still permits part capacity to hold temperatures.

The "Blast Air" freezing system involving evaporator design as shown in Fig. 3 is gradually becoming popular for quick freezing. These systems employing a booster compressor are operated automatically so the system is always ready for production. This also permits 8 to 24 hr. per day of freezing at any intervals. The high pressure machinery in many cases operates continuously on holding rooms and is often manually controlled. The automatic booster compressor does not require the operator's attention and is always ready for service.

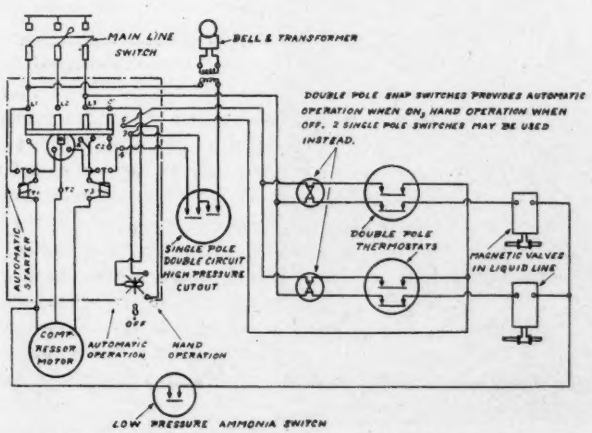

MAIN LINE SWITCH
BELL & TRANSFORMER
DOUBLE POLE SNAP SWITCHES PROVIDES AUTOMATIC OPERATION WHEN ON, HAND OPERATION WHEN OFF. 2 SINGLE POLE SWITCHES MAY BE USED INSTEAD.
AUTOMATIC STARTER
SINGLE POLE DOUBLE CIRCUIT HIGH PRESSURE CUTOUT
DOUBLE POLE THERMOSTATS
MAGNETIC VALVES IN LIQUID LINE
COMPRESSOR MOTOR
AUTOMATIC OPERATION
HAND OPERATION
LOW PRESSURE AMMONIA SWITCH

Fig. 5. Electrical connections for a typical multiple room system

Humidity in Industry

INDUSTRIAL APPLICATIONS of air conditioning, particularly in the textile field, have been numerous and more or less successful. In a paper presented before the Institution of Heating and Ventilating Engineers, M. C. Marsh reviewed the status of air conditioning in England, primarily from the standpoint of work which he has done in recent years for the Wool Industries Research Association. This work on the whole has been primarily concerned with humidity control rather than air conditioning as we know it in this country.

In this paper he said that the best humidity for any textile process lies between the limits of 40 per cent, below which there is danger of static electricity, and 85 per cent, above which there is danger of mildew. The optimum for any process depends upon the raw materials, the oils used and the adjustment and speeds of the machines used in the plant so that experiment is advisable to get the best results. The tabulation, however, was quoted as a guide.

Optimum humidity limits for different textile operations

	Per cent.
Cotton:	
Carding	45-55
Combing	60-65
Spinning	60-70
Weaving	75-80
Woolen:	
Carding	65-70
Spinning	55-60
Weaving	50-55
Worsted:	
Carding (Bradford System)	65-70
Combing "	60-70
Top storage "	85-90
Drawing "	50-60
Spinning "	50-55
Combing (French System)	65-70
Drawing "	65-75
Spinning	75-80
Weaving (Bradford or French System)	50-55
Silk:	
Throwing	60-75
Dressing	60-65
Spinning	60-70
Weaving	60-70

Steel Mill Explosion

EARLY on the morning of March 2 a boiler room explosion in Chicago wrecked No. 3 Boiler House at the South Works of the Carnegie-Illinois Steel Co. One battery of boilers was completely demolished and a 170 ft. stack, sheared off at the base about 25 ft. from the ground, fell across the plant crushing the building steelwork and breaking all gas, steam and water lines. Seven men were in the building at the time. Two escaped, two were instantly killed and the remaining three, together with two men in an adjoining building, were injured. One of the injured men died subsequently as the result of burns.

In service since 1906, the boiler room had ten 325 hp. Rust boilers, with cast iron economizers, set in batteries along the east building wall. The ten boilers were served by three stacks with four boilers on each of the two north stacks and two boilers on the third or south stack. Blast furnace gas was being burned at the time, but both natural gas and oil were available as auxiliary fuels.

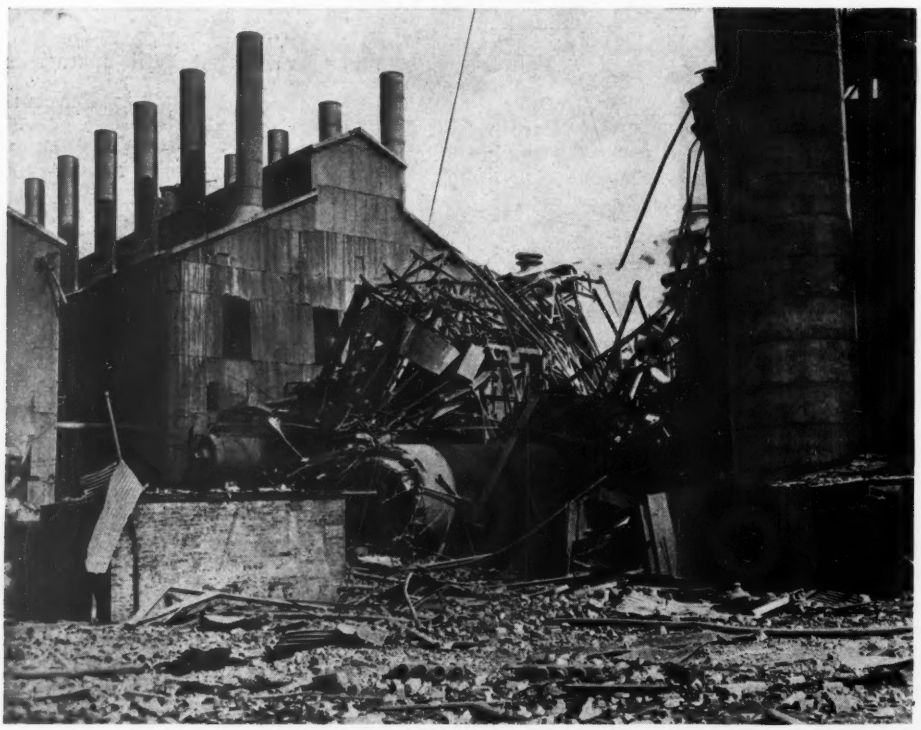
Rust boilers, quite widely used during the early part of this century, have two banks of vertical water tubes and four short cross drums, two steam and two mud drums. Six of the drums from the demolished battery were found at or close to the original position of the boilers. One of the front steam drums, however, traveled a distance of 875 ft. southeast, at a steep angle, to clear an adjoining building and gas holder. The second front steam drum traveled east, horizontally across the boiler room, and struck the crane rail of the adjoining power house. The cause of the explosion has not been determined.

Cotton Hose for Humidity Control

IN A DISCUSSION of humidity control in industry, before the Institution of Heating and Ventilating Engineers, J. McIntyre mentioned an interesting installation recently made in England. The dry bulb temperature was not controlled and the temperature varied from summer to winter. For humidity control, an ordinary recording hygrometer, with a rotating drum and clock, was used. The needle was rebalanced and two small mercury contact cups inserted, one of which started the spray apparatus, to increase the water vapor content of the air, and, the other to start the fan which did the drying.

The method of taking the moisture out of the air was interesting. Refrigeration was found to be expensive and textile material was used. Because of its greater moisture content, wool would have been preferable but was too expensive, so, about a ton of old unlined canvas fire hose, scrapped from fire service, was placed in a drying battery in ducts.

In the control, the recording pen and contact levers were actuated by a single human hair. These hairs vary considerably in response. These hair instruments were said to be reliable enough for this purpose within narrow range of relative humidity with variations of 10 per cent or more in the reading. There is, however, a creep and the needle must be reset at least twice a week.



North end of the boiler plant showing the stack which fell across the demolished battery of boilers and wrecked the building steelwork

Tribune Photo

Drying Flooded Electrical Apparatus*

These suggestions may come too late to be of much use in connection with the recent floods but they may be of great value at some future time. Study them over carefully

A POWER HOUSE after a flood is a sorry sight—oil, mud smeared over everything, unlimited driftwood, debris, and sand everywhere. The first step is a thorough cleaning of everything, and this should be started at once, along with a plan to provide heat to the building, while a general plan of drying is laid out.

Clean water under moderate pressure can be used to wash out sand and silt. Too much pressure may cause damage to insulation that may be brittle from age and heat. Rinse with hot water if possible.

Oil, grease, and sludge may require some solvent. Several of the oil companies put out cleaning solvents that are non-explosive, and some one of these or straight carbon tetrachloride should be used to avoid the great danger of explosion and fire that goes with the use of gasoline or any similar hydrocarbon. It must be remembered that the vapor of any of these solvents is heavier than air, and there is the ever-present danger of suffocation to the men using them. In addition, carbon tetrachloride is poisonous to many men and will cause sickness to others. It often acts like chloroform to cause intoxication. Cleaning should, therefore, be done in the open air where men may work

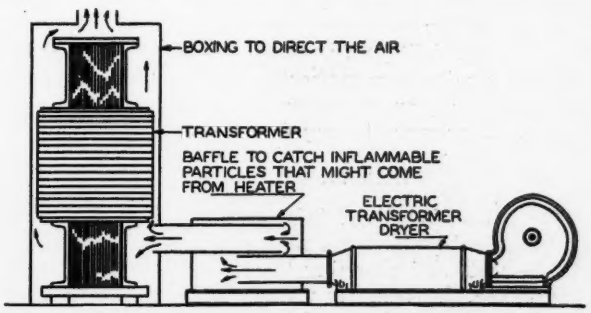

BOXING TO DIRECT THE AIR
TRANSFORMER
BAFFLE TO CATCH INFLAMMABLE PARTICLES THAT MIGHT COME FROM HEATER
ELECTRIC TRANSFORMER DRYER

Fig. 1. Method of Using Electric Transformer Dryers

up wind, or else some positive means of avoiding the vapors should be provided. An exhaust fan with its suction under the apparatus being cleaned, and, with its discharge outside the building, is the best and surest protection to the men.

As soon as possible, open up all bearings, clean them thoroughly, get all parts dry, and coat all bearing surfaces with moisture-free oil to prevent rusting. All oil piping, tanks, pumps, etc., should be thoroughly cleaned. In many cases large amounts of sand have been found and it has been necessary to dismantle all the piping and blow it out with compressed air or steam.

*Abstracted from instructions issued by the General Electric Co.

The second step is the drying of the equipment, and here the best method in any specific case will be determined by local conditions and the facilities and equipment available.

In general, heat and dry air are necessary to remove moisture. A temporary oven can be built of lumber, sheet iron, or any of the many insulating materials, for the small equipment that can be easily moved; or such an oven can be built around large apparatus. Electric heaters, steam coils, stoves, or hot-air furnaces may be used for heat. First, be careful to avoid fire risks; and, second, provide for a positive air circulation. Salamanders or open flame heaters should be avoided. The dust, soot, and fumes from them may make matters worse. Clean dry air and plenty of it should be provided. Oven temperature should be raised to 80-90 deg. C. to get satisfactory results, and the air must be allowed to escape as it becomes moisture-laden. Continued heating in an oven filled with moisture-saturated air may make matters worse instead of better.

Small equipment can be moved to baking ovens, dry kilns, or to a room or temporary enclosures rigged up for drying. Electric range ovens can be used for meters, relays, and other small parts. In any case the moisture-laden air must be expelled.

If generators can be turned over, even at reduced speed, the drying will be speeded up materially, first, by throwing out any trapped water, and secondly, by the natural fan action forcing a circulation of air to all parts. Motors should be turned over by hand occasionally while drying, to allow trapped moisture to run out.

It should be remembered that equipment is usually considerably warmer than the flood water; a vacuum may be caused as the machine cools, and water may be sucked through very small joints—so small that the water cannot get out when drying starts. This is shown in the case of a station containing three turbine-generators. Unit No. 1 had been shut down several days, unit No. 2 several hours, and unit No. 3 was shut down just before the station was flooded. Satisfactory insulation resistance was obtained first on No. 1, then No. 2, and finally on No. 3.

A vertical generator was dried several days in a temporary oven. The field showed little gain in insulation resistance to ground. It was started and brought up to speed. A large amount of water was thrown off and the insulation resistance rose very quickly.

A large motor was turned over after some days drying and a large amount of water was dumped out. After that, the machine was turned over every few hours, and the drying was speeded up considerably.

Insulation resistance to ground should be taken as soon as the drying starts and should be checked at regular intervals thereafter. Keep a careful record of each machine, for the change of the resistance to ground gives an indication of the drying results. Usually the resistance will drop as the machine warms up, reach a minimum, and then start to climb—rapidly at first and then slowing up as the moisture is driven out.

Insulation resistance cannot be relied upon as a sure indication of its condition at any one time. The general trend of the readings as a drying run proceeds is a fairly accurate indication of the progress of drying. Continue the drying until the readings become approximately constant at a value considerably above the low readings.

Current transformers have been baked until they showed "infinity," and when they were turned over in taking them from the oven a cup of water ran out. Compensators have shown "infinity" yet failed when voltage was applied; water was found trapped in the windings. No current should be applied to a winding indicating ground or an insulation resistance less than around 50,000 ohms. When the drying out has reached a point where it is considered safe, a.c. generators can be put in a short-circuited heat run. The current should be brought up slowly and temperatures carefully watched both in the windings and the core. Some turbine-generators having a large "throw" or span of the end windings and large amperage per slot may develop high temperatures in some of the teeth of the core. Temperature-indicating coils that are located to show the temperature of the coils under load will not show these hot spots. Since this heating is a function of the speed, short-circuit drying should be done at one-third to one-half speed. (*Caution*) One-half speed must not be exceeded under any circumstances.

D.C. Generators and Exciters

Commutators usually give the most trouble because water is sucked under the bars and cannot be driven out by outside heat. The water must be drained out and some method used for getting hot, dry air under the bars. The outside clamp rings may be taken off entirely on small armatures, and the armature upended to drain. On larger machines, every alternate clamping bolt may be removed.

A coil of pipe or old steam radiator, heated by a fire or gas torch, will heat compressed air and this hot air can be forced in under the commutator bars. Commutators can be heated by strip heaters wrapped around the outside or space heaters clamped to the commutator surface. Temperatures as high as 130 deg. C. have been used with this method without apparent damage or distortion.

If the machine can be driven at reduced speed, small air scoops like ship ventilators may be fitted in every alternate open clamping bolt hole to cause an air circulation under the bars.

Commutators have been heated by plumbers' furnaces, turned low and set under them. Don't, in any case, apply flame direct to the commutator; use air over 100 deg. C., or get the commutator above 100 deg. C. for fear of softening the mica sticker or disturbing the commutator. Watch the commutator spider, for too rapid heating may expand the spider and cause it to work off its seat on the armature hub.

A heated enclosure or oven for large d.c. motors is recommended, with hot air blown under the commutator bars. Arc-welding sets have been used to circulate current through the shunt fields of large mill motors. This has given good results in some cases and failed in others. Apparently, water was sucked into some compound-filled coils through small checks in the compounding and could not escape when the coils were heated.

Watch compounded field coils carefully when drying with current to see that the temperatures are not high enough to melt or soften the compound. *Note*: In drying shunt fields, we are opposed to using current in wet coils because we have found some cases where current applied to water-soaked coils has leaked between turns, and electrolysis has apparently deposited copper salts in the cotton covering.

A d.c. generator may be run short-circuited when direct current is available for separate excitation. The series field should be reversed to buck the shunt field, and the generator short-circuited through an ammeter and circuit breaker or fuse. Then a very small current is sent through the shunt field and gradually increased until full-load current flows through the short circuit.

Induction Motors

Slip-ring motors can be dried by short-circuiting and blocking the rotor and applying about 20-25 per cent voltage to the stator windings. The voltage should be adjusted to get a temperature of around 90 deg. C. in the stator and rotor windings. The rotor should be moved occasionally to permit water pockets to drain.

Where there are a number of motors of similar size and voltage, connect them 5 in series, single phase at line voltage. Do this by putting two phases on each motor together to one lead and the other phase to the next motor. With a two-phase motor, use one phase for the single-phase connection and connect the ends of the other phase together. Hold the temperature of the windings under 90 deg. C.

Synchronous Motors

These are best dried in a temporary housing heated to 90 deg. C. with some means of circulating the air to all parts and changing the air as it becomes moisture-laden. It may save time in some cases to remove the poles and dry them in an oven, especially if the insulating collars need replacing.

Cables

Control cables should be pulled out of their conduits and inspected. If the insulation is in good condition, place the reels in ovens to dry out. If it is in poor condition, replace with new cable. All conduits should be flushed to remove silt, and should be blown out and dried before the cables are replaced. It is almost impossible to get water out of large, lead-covered cables, especially if it has entered the copper. It is recommended that such cable be replaced. However, there are some cases where varnish-cambric cables have operated with water in the copper or inside the lead.

Wet paper-insulated cable should be replaced.

Transformers

The forced air method of drying is preferable for rectangular-coil shell-type transformers because of the mass of solid insulation, and for any transformer that is water-soaked. It consists of forcing clean, dry air at a temperature of 85 deg. C. into the coils and insulation at the bottom of the transformer, allowing the air to escape at the top. The quantity of air used should be such that the temperatures of the ingoing and escaping air are about the same.

The quantity of air to give good results varies approximately with the size of tanks and therefore can be gauged as follows:

Average Diameter of Trans. in Inches	Cubic Feet Air per Minute
54 to 72, inclusive	600
78 to 96, inclusive	900
102 to 120, inclusive	1200
126 to 144, inclusive	1500
150 to 168, inclusive	1800

It is best to remove the transformer from its tank and surround it with a casing, using pipes and deflectors so that the hot-air draft will reach all parts of the winding. This is especially necessary with core-type transformers having horizontal ventilating ducts. Do not let oil run from the transformer into the heater, for it may cause a serious fire. To prevent fire risk, place a baffle in the pipe line between the heater and the transformer, so that if for any reason trouble occurs in the heater, sparks will not reach the transformer. This baffle may be made from a section of sheet-iron pipe covered with asbestos and should be approximately 16 in. in diameter and 48 in. long arranged as indicated in Fig. 1.

Temporary electric heaters may be made from iron wire, mounted on porcelain knobs on a framework of strap iron. Wind 125 turns of No. 13 B.W.G. telephone wire on a half-inch pipe mandrel. Pull this coil out a bit and try it on 125 volts, and lengthen or shorten as necessary. It should get almost red hot and take around ten amperes. Coils for use on alternating current will be somewhat shorter because of the reactance.

It is sometimes necessary, in an emergency when no blower is available, to dry a transformer by external heat, allowing the hot air to circulate by natural draft. The source of heat may be resistance grids or a steam coil.

If resistance grids are used, arrange to run them at a comparatively low temperature to avoid risk of fire, and do not place them directly under the transformer where oil might drip on them and be ignited. They may be placed in a suitable box of fireproof material a short distance away, and the hot air led to the transformer by a pipe. The transformer must be boxed in so that the boxing will act as a flue to maintain the draft. Provide dampers in the heat box to regulate the flow of air. Place thermometers to read the temperature in the pipe between the heater and the transformer and also to read the outgoing temperature. The ingoing temperature should be between 80 and 85 deg. C. To insure uniform drying, the volume of heated air should be such that the outgoing temperature will not be noticeably lower than the ingoing. In general, it will take 15 to 25 kw. to dry a transformer of about 2500 kv-a.

Industrial Minerals In 1936

Production of almost all classes of industrial minerals increased in 1936, confirming the broad uptrend since 1932. Compared with 1935, the improvement in most groups was quite marked, averaging probably between 10 and 20 per cent, although still lagging behind the recovery in general business on account of the low rate of building activity, the dominant outlet for leading tonnage items. Industrial output for the country as a whole has come back almost to where it was at the pre-depression peak, the Federal Reserve Board index advancing to 114 in November (1923 to 1925 = 100), the average for the year being about 105 as against 90 for 1935. Construction activity, however, notwithstanding an increase of almost 60 per cent over 1935, was still scarcely 40 per cent of the 1928 peak volume. Residential building was only 30 per cent of that reported in pre-depression times, amounting to but 800 million dollars for the year albeit 70 per cent more than in 1935. Total construction in 1936 approached 3 billion dollars, about evenly divided between private and public works. Fluxing limestone, refractories, and a number of other industrial minerals benefited from the high rate of iron and steel production. The glass industry, an increasingly important outlet for sundry nonmetallic minerals, was extraordinarily active. Chemical industries, after weathering the depression better than most other industries, continued to improve, a condition that was shared to somewhat less degree, by the fertilizer branch of the group. Paper making, particularly the divisions that use large quantities of clay, was on the upgrade. In fact, nearly all the industries that consume industrial minerals were approaching normal with the single exception of construction.

Whereas the steel and automobile industries are employing more people and paying higher wages than ever before in their histories and most factory workers are re-employed, the mining industries have found difficulty in providing as many jobs as they did a decade ago. The number of men at work in quarries and nonmetallic industries is scarcely more than 50 per cent of that employed in these industries in 1929, a much poorer showing even than that made by the metal mines. The index of general factory employment rose to above 90 per cent for 1936 as against 85 per cent of the 1923-1925 average in 1935. However, employment in factories making stone, clay, and glass products rose to only 65 per cent compared with 59 per cent a year ago. In the glass industry alone, the monthly index rose well above 100 per cent but employment in brick, tile, and terra cotta works, although it jumped sharply in the early months, failed to advance much beyond 43 per cent of the 1923-1925 average. Potteries were working more actively, with employment above 75 per cent of normal; but marble, granite, and most of the stone industries other than slate exhibited little improvement, the average for the stone industries being less even than in 1934 although bettering somewhat the 34-per cent figure for the previous year. Cement plants formed an intermediate group, with the employment index rising from 43 per cent in January to 60 per cent toward the end of the year, notwithstanding an increase in shipment to almost 90 per cent of the 1923-25 level.—U. S. Bureau of Mines.

POWER PRODUCTION With Iowa Coal*

Through scientific methods of furnace development, Iowa coals have been brought into the class of satisfactory and economical fuels for power plants

By John M. Drabelle

Mechanical Engineer, Iowa Electric Light and Power Co.

WITH THE advent of scientific methods of fuel burning, there came as a result, due to the development work of manufacturers, such devices as the steam flow meter, that indicated to the fireman on duty the amount of steam being generated by the boilers, draft gages, more efficient and better stokers, feedwater regulators, and many other devices, all of which contributed greatly to the ease and the more efficient operation of the boiler plant.

The producer of solid fuel is necessarily deeply interested in not only the present market, but the future market. In the central station power industry we have just about reached the limit of reduction in the quantity of coal used to produce a kilowatthour until the chemist provides us with a new and at present unknown working fluid to replace water, which is, of course, the universal working fluid today for the production of steam; also until the metallurgist gives us some new metal which will satisfactorily give pressures in excess of 1400 lb. per sq. in. and temperatures in excess of 1000 deg. F. The steady reduction in the heat rate, so-called, of power production in central stations has, of course, had a marked effect upon the consumption of coal in towns. This was further complicated by the depression, which we have been passing through, which reduced the central station output generated by solid fuels.

With the advent of air-conditioning, which, like the stream-line train, has appealed to the public mind like nothing else has in recent years, I am making the prediction that the coal requirements of the central station industry will be greater in the summer than in the winter within a very few short years, due to the

*Abstract of paper before the Solid Fuels Conference, Iowa State College.

Table I. Iowa Electric Light and Power Co. Boiler Test Data

PARTICULARS							
LOCATION	Boone	Boone	Perry	Perry	Perry	Perry	Perry
Make	Edgemore	Edgemore	B. and W.	B. and W.	B. and W.	B. and W	B. and W.
Rated H. P.	410	410	500	500	500	500	500
Active Grate Area	94.5	94.5	126	126	126	126	126
Baffling	Original	Revised	Revised	Revised	Revised	Revised	Revised
Furnace Volume	246	386	1,835	1,835	1,835	1,835	1,835
Rating in %	156	180	105	145	158	200	129
Draft over Fire	.21	.205	.22	.25	.191	.241	.20
Draft Loss Through 1st Pass	.01	.08	.18	.166	.228	.250	.17
Draft Loss Through Superheater	.22	.12	.061	.05	.060	.065	.05
Draft Loss Through 2nd Pass	.19	.165	.246	.21	.234	.240	.21
Draft Loss Through 3rd Pass	.10	.18	.18	.156	.186	.18	.18
Draft Loss Differential	.53	.54	.685	.60	.725	.754	.62
Draft Stack	.78	.74	.912	.85	.924	1.00	.85
Stack Temperature	491	528	486	492	523	553	490
Steam Temperature Total	491	483	538	549	551	559	540
Steam Pressure	170	182	223	227	209	217	225
Steam Superheat °F.	116	103	142	152	160	166	143
Feed Water Temp. °F.	212	211	210	210	210	210	210
Length Test in Hours	3	3	3	3	3	3	24
Pounds Coal Burned	13,110	12,670	8,400	9,700	10,900	14,600	69,000
Pounds Water Evap.	78,000	80,000	47,674	63,100	70,952	89,776	463,360
Av. Hourly Evap. Lbs.	26,000	26,800	15,891	21,720	23,651	29,925	19,300
Lbs. of Coal Burned per Sq. Ft. per Hr.	46.2	44.7	22.2	25.7	28.8	38.6	22.8
Water Evap. per Lb. of Coal	5.95	6.3	5.78	6.73	6.5	6.15	6.72
Kind of Coal	Scandia	Scandia	Scandia	Scandia	Scandia	Scandia	Scandia
B. T. U. of Coal as Fired	8,617	8,462	9,190	9,190	9,018	9,018	9,219
Total Heat of Steam	1,264	1,286	1,286	1,290	1,292	1,297	1,285
Boiler and Furnace Eff.	74.2	80.0	70.0	81.3	80.5	76.2	80.4

advent of air-conditioning and its attendant electrical load upon the public utilities. Today the electric refrigerator is a device which has been accepted by the public and is to be found in a large percentage of the homes; likewise, the air-conditioning load is just around the corner,—in fact, it has turned the corner.

Improvement in fuel burning is a crying need in industrials, private buildings and public institutions. With the improved burning conditions will be found an increased customer satisfaction in the use of solid fuel which will mean a return of much of the business which has gone to oil and natural gas to solid fuels, thereby providing permanent jobs the year round for the coal miner and the railroad men.

Furnace Design

Furnace designs in Iowa initially were merely copies of the work that had been done in Illinois, which again was largely a copy of the designs in other states. No real attempt had been made to determine carefully the characteristics of the fuel being burned and to adapt to that fuel the fuel-burning mechanism, the stoker, and the furnace in which it was burned. Too often attempts have been made to force the coal to conform to the fuel-burning equipment, which, of course, is obviously impossible. In power stations, the early designs, so far as water tube boilers were concerned, consisted of a flat horizontal arch suspended but a relatively short distance above the stoker. This gave a very high heat release in the furnace accompanied with high temperatures and a clean stack, but it was difficult if not impossible to secure steaming capacity in output, much above the normal horsepower rating of the boiler. As time went on, various experiments and studies were made, and as experimental work had to be done on the existing equipment, stoker and furnace changes that could be made, as to increasing furnace volume and dimensions, were necessarily very limited in character, but nevertheless certain fundamental principles were determined. These basic principles are the proper tempering of the coal. That is actually the addition of moisture to the fuel before it is fired for the purpose of cementing together the smaller particles of coal so as to render the fuel bed more porous and to permit of a greater quantity of air to pass through the grates.

Turbulence

With the small volume furnaces previously mentioned, brick work maintenance was necessarily extremely high due to very high heat release per cubic foot of furnace volume. With the larger furnaces came an increased volume and length, a lower heat release, and more time for the combustion process to take place. The newer furnaces were designed so as to secure turbulent flow of the gases so that the oxygen of the air supplied for combustion might come thoroughly in contact with the fuel gases being distilled from the fuel bed.

In order to burn large quantities of coal per square foot of grate area and to secure high output per boiler, increased draft was absolutely necessary. Most of the smoke stacks were relatively too short and did not give adequate draft, but by increasing the height of the stack, which consequently increased the draft, much improved overall results were secured.

This, however, led to another problem. This problem was baffling of the boiler so as to secure the proper flow of gas over the heat-absorbing surface of the boiler and also to provide proper soot-blowing equipment for the removal of the soot and fly-ash. Anyone who has observed the action of his own heating furnace in the home has noted that when a shovel full of fresh coal was thrown on the fire, rich, yellow gases are seen to come off the coal. This is the first step in the combustion process, and as Iowa coal contains a relatively large amount of volatile matter, approximately 38 to 42 per cent, the proper combustion of these fat gases is absolutely necessary. There was introduced to the furnace through the arch a supply of air under pressure. This is known as over-fire air and there has not been a case of a smoking stack that has come to my attention that could not be cured or at least considerably reduced as to smoke-producing qualities by merely introducing some air over the fire at a point where there is a definite lack of oxygen to support combustion of the fat gases.

Progress

On March 8, 1934, the Iowa Electric Light and Power Co. reported on the progress and the history of that company's work in the developing of furnaces suitable for the burning of Iowa coal covering a period from 1911 to 1933. The last boiler at that time reported to you was the design of 1933 at Perry, Iowa, power station. A tabulation of our work from 1911 to 1933 is shown in Table I.

Dr. Ollin of the State University and Dr. Sweeney of the Iowa State College have reported to you in detail as to the chemical characteristics of our Iowa fuel. A typical analysis of Iowa coal is as shown in Table II.

Table II. Typical Analysis of Iowa Coal

Rated As Constituents	Good	Fair	Bad	Fair Perry Test
Moisture ..... %	7.88	12.36	14.42	14.81
Volatile ..... %	38.83	37.65	29.29	N.D.
Fixed Carbon ..... %	34.42	31.94	30.00	N.D.
Ash ..... %	16.23	18.06	26.29	18.2
Sulphur ..... %	4.75	5.75	7.00	4.85
B.t.u. Commercial ..	10,476	9,712	7,118	9,219
B.t.u. Dry Basis....	11,774	11,081	8,316	10,932

N.D.—Not Determined.

I have mentioned to you furnace volume, boiler rating, grate area, and I believe it will bear repeating a summary of our work as shown in Table III.

Table III. Summary of 20 Yr. Development

	Boiler Rating HP.	Grate Area Sq. Ft.	Furnace Value Cu. Ft.	Boiler Rating %	Av. Evap. lb.
Design of 1912.....	410	81	246	125	5.5
Design of 1920.....	410	81	259	150	6.0
Design of 1924.....	410	96	409	180	6.35
Design of 1931.....	410	96	386	200	6.50
Design of 1933.....	500	126	1,835	250	6.70

The Iowa Electric Light and Power Co. has under construction at Boone two 500 hp. boilers similar to the Perry boilers, and on account of certain space limitations in the old boiler house in which these will be installed with this type of setting adopted at Perry with the following deviations:

1. The stoker will be a forced blast stoker.
2. The furnace side and the rear walls are covered with water tubes for the dual purpose of reducing brick work maintenance and absorbing a considerable quantity of heat in the furnace. The amount of water-cooled surface in the furnace is approximately 500 sq. ft.

With these changes it is expected that this boiler, similar to the boiler at Perry, will be capable of producing from 50,000 to 55,000 lb. of steam per hour, whereas the Perry boiler has been able to do is a maximum approximately 35,000 lb. of steam per hour.

At Cedar Rapids, Iowa, another interesting development has been taking place, namely, that of the water-cooled, under-feed stoker. The principal difficulty with the under-feed stoker has been, as it was originally designed, that when operated at high combustion rates with fuels that have a large quantity of ash and also an ash which fuses at relatively low temperature, that continuous operation was almost impossible except with a prohibitively expensive large grate area, with consequent low burning rates per square foot of grate area. The application of water-cooling tubes along the tuyers of this type of stoker produces a radical change in its operation and the character of the fuel bed. The ash which normally runs and fuses into large tombstone-like clinkers, now flashes almost as it forms, into small, easily-handled clinker fragments. We are now erecting a new high pressure boiler having an output of approximately 300,000 lb. of steam per hour at a pressure of 750 lb. gage and a total temperature of 750 deg. F. The furnace will be completely water-cooled and the stoker will be of water-cooled under-feed type. This installation is not as yet completed or placed in operation and consequently no test results can be reported, but we feel very certain that this will open up a new field of development in the use of Western coals.

There is available today through the technical press and various trade books and publications of all kinds, data on various types and kinds of coal and coal-burning equipment that has been either a success or failure, as the case may be. There is no real reason today why the owner of a power plant should suffer from a smoky stack, a high steam cost per unit output, high brick work maintenance, or other troubles, if he will but spend a little money and get some person actually familiar with the fuel at hand.

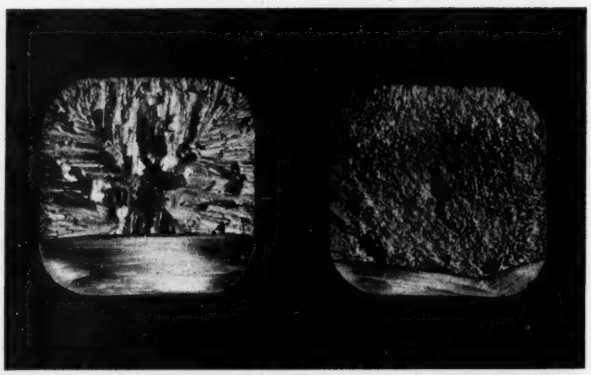
Modified Chromium Steel

CHROMIUM STEELS are more widely used than ever before by almost every important industry—automotive, aviation, railroad, ship, construction, mining, petroleum, chemical, food—for heat-resistant and corrosion-resistant applications and for added strength in structural applications. Modifications such as new gradations of chromium content and suitable additions of other elements have been made for specific applications.

These modifications include a molybdenum-bearing 9 per cent chromium steel suitable for severe service in petroleum refineries and power plants. For high-pressure service, where resistance to shock and the decarburizing effect of hydrogen at high temperature is required, good results are obtained with 1.50 to 2.75 per cent chromium and the addition of molybdenum and vanadium. Another modification is a columbium-bearing 2 per cent chromium steel. The 4 to 6 per cent chromium steels themselves have been modified and improved by additions of columbium or titanium, while the creep strengths of 4 to 6 per cent chromium steels containing tungsten or molybdenum, used for condensers and tubing in oil cracking, are improved when columbium is added.

The prime function of columbium is to control the carbide constituents of chromium steels. There have long existed many possible applications in which plain chromium steel would have proved exceedingly useful had its air-hardening characteristics been modified or eliminated.

Columbium is used in 18-8 chromium-nickel stainless steel welding rods, and either columbium or titanium in the stainless base metal to inhibit any tendency toward intergranular corrosion that might otherwise be present in or near welds. The amount of columbium



Photographs taken by the Electro Metallurgical Co. show the effect of nitrogen on grain structure of a 20 per cent chromium steel. Left without nitrogen, right with nitrogen. The nitrogen, about 1 part to 120 parts of chromium, is introduced as a high-nitrogen ferrochrome

added is determined by the carbon content of the steel and by the temperature at which it is to be used. With correct amounts of columbium in these steels it is not necessary to anneal structures fabricated by welding in so far as obtaining freedom from intergranular corrosion is concerned.

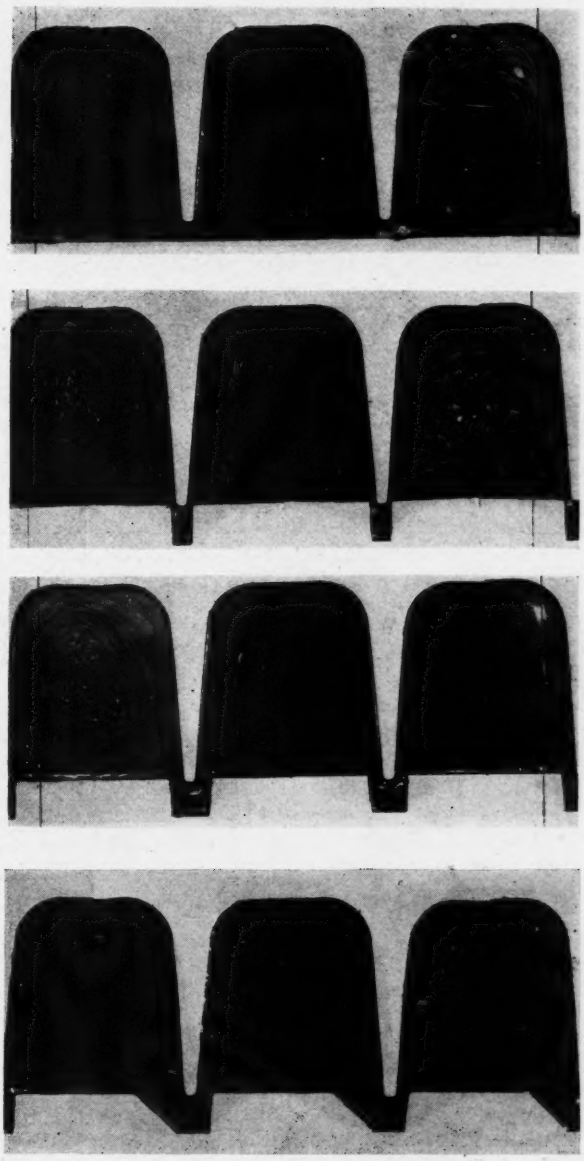
Another important modification of the high-chromium steels with which steelmakers and foundrymen are becoming familiar is the addition of nitrogen to improve the grain structure. Steel castings containing over 20 per cent chromium have been in use for many years in applications where resistance to corrosion, to high temperatures, and to excessive wear is desirable. Such castings have shown a tendency toward the formation of a large grain structure and toward grain growth when held at a high temperature for long periods. The addition of nitrogen to such alloys has the effect not only of reducing the tendency to grain growth at high temperatures, but also of refining the grain. This results in a marked increase in the ultimate strength, yield point, elongation, and reduction of area.

Flow Through Labyrinth Glands

New laboratory technique gives quantitative results on leakage and throws new light on mechanism of throttling flow

By Dr. C. Keller,

Caloric Research Laboratory,
Escher Wyss Engineering Works, Ltd.,
Zurich, Switzerland



LEAKAGE along shaft glands and diaphragms of compressors, blowers, steam and gas turbines is a source of considerable loss with modern high pressures. In order to reduce these losses to the minimum without impairing the reliability of such machines, an exact knowledge of what occurs in the labyrinth chambers is required.

Systematic tests made formerly with labyrinth-glands were carried out with full size glands under steam pressure to find means to ensure efficient sealing. This procedure gave an idea of the total losses but did not permit observing the peculiarities of the steam flow nor explain the mechanism of the throttling problems.

In the laboratories of Escher-Wyss such gland problems are now handled by new test methods on oversize models and the results, applied to practical work, have led to important developments in the sealing possibilities in restricted spaces. The latest patented Escher-Wyss design of carbon labyrinth-gland is shown by Fig. 1. The surface opposite to the throttling fins proper consists, in this new design, of inserted carbon segments of a special quality to withstand prevailing pressures and temperatures.

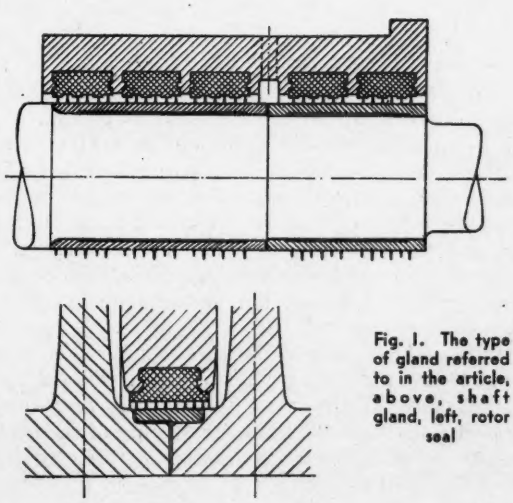


Fig. 1. The type of gland referred to in the article, above, shaft gland, left, rotor seal

In order to obtain a sound foundation upon which to develop this new design, tests were made with regard to the formation of eddies in labyrinths and the volume of leakage fluid with various shaped chambers. Water was used as demonstrative fluid. A tank, Fig. 6, feeds varying quantities of water to a relatively deep, short channel which contains built-in throttling fins. This channel represents a section through a part of a labyrinth magnified about 40 times. The stream paths and eddies in the water in an enlarged model are similar to those in geometrically similar labyrinths of actual machines.

Fine sawdust is strewn on the surface of the water in order to make the stream lines clearly visible. The different velocities occuring at individual spots in the chambers are represented on instantaneous photographs by white lines of different length, which correspond to the path of the light colored wooden particles. Slow moving or idling particles, for instance,

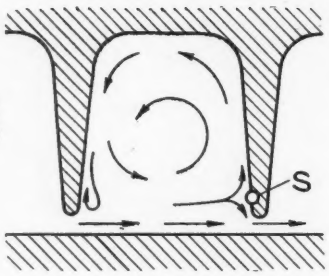


Fig. 2. Flow through shape g of Fig. 7. Starting condition with a clearance of about 0.3 mm.

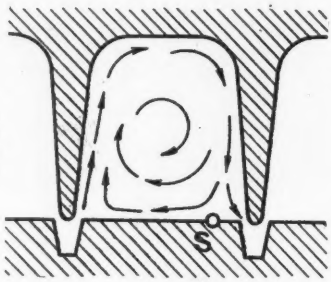


Fig. 3. Flow through shape a of Fig. 7. Grooves have been cut into the stationary carbon surfaces after whipping of the shaft about 0.6 mm.

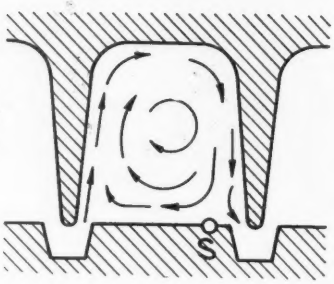


Fig. 4. Flow through shape d of Fig. 7. The carbon stationary surface groove has been widened due to axial displacement

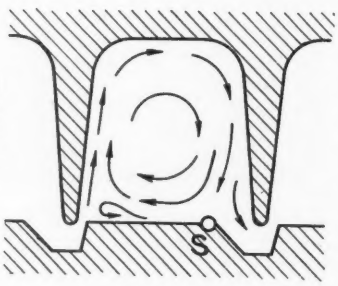


Fig. 5. Flow through shape f of Fig. 7. Representing 0.6 mm. radial whipping of the shaft, axial displacement toward the right with simultaneous radial heat expansion

in the center of the chamber, show up as points, fast moving ones as white dashes.

That part of the model bearing the fins corresponds to the rotating shaft with its throttling fins, the opposite side represents the stationary part of the gland (in other words, the carbon of the carbon labyrinth-gland). The illustrations, Figs. 2 to 5, show the currents set up in the chambers of carbon labyrinth-glands during different operating conditions of a machine, as, for instance, warming up, starting, normal service, running after a period of vibration. In all illustrations the direction of flow is from left to right. Glands of this type are compared, as far as leakage flow is concerned with labyrinth-glands of well known types having metallic counter surfaces, in Fig. 7.

Fig. 2 shows conditions as they may prevail when starting up a compressor or steam turbine. The clearance between fins and opposite wall is 0.3 mm. (hence on the model 12 mm.). The leakage flow leaving a labyrinth chamber at high velocity shoots unhindered towards the next throttling gap and owing to this originally small clearance it is dammed up near point S of the wall of the next fin.

A great part of the flow is then directed along the wall of the fin upwards against the bottom of the chamber, losing its kinetic energy through internal friction in the strong eddy which rotates counter-clockwise in the labyrinth chamber. Only a relatively small part of the flow enters directly through the next gap into the following equalizing chamber. Owing to the originally small clearance the throttling action, even with the use of smooth unstepped opposite walls, is relatively satisfying.

In older types of labyrinth-glands the counter-surfaces to the fins have been metallic. This resulted in a fast grinding away of the sharp, quickly rotating fins as soon as only the slightest whipping of the shaft occurred, so that the narrow original clearance could never be maintained for a long time and frequently the actual clearance soon became a multiple of the original one.

Flow Lines

In this case the flow along the counter-surface shoots practically as a whole from one throttling spot to the next without any damming or splitting up of the stream. Due to the high entrance velocity to the gap, the pressure drop is small and therefore the throttling action is insufficient. Only a feeble eddy rotating slowly counterclockwise can be noticed in the labyrinth chamber, the rotation being chiefly maintained by the friction on the fast flowing particles of the main stream passing along the counter-surface. It is quite clear that for such conditions leakage losses become large.

When the shaft with the new Escher-Wyss carbon labyrinth gland whips, the metallic fins simply cut grooves into the carbon without being worn themselves. As soon as the shaft runs true again, the conditions as illustrated in Fig. 3 prevail; in this illustration a whipping of the shaft of about 0.6 mm. has been assumed. The character of the flow has now completely changed as compared with the first figures. The jet issuing from the throttling gap shoots along the right flank of a labyrinth fin at high speed into the labyrinth chamber and against the bottom of the latter. A very strong eddy rotating clockwise is thereby created, the outer layers of which flow along the walls of the chamber with considerable friction.

Due to this reversal of the rotation, the flow is no longer dammed up on the next fin, as in Fig. 2, but hits the counter wall in front of the next throttling point. A large portion of the current now flows from right to left along the stationary carbon surface and therefore would even oppose a direct leakage stream from gap to gap, if there should be one. The strong eddy rotating clockwise uses up considerable kinetic energy which increases the pressure drop from one chamber to the other.

It is possible that owing to a difference in expansion due to heat in actual operation, the shaft may extend more axially than the non-rotating counter part. If a shaft should whip, a widening of the grooves already cut into the carbon results. In this way shapes may be created as shown, for instance, in Fig. 4 which

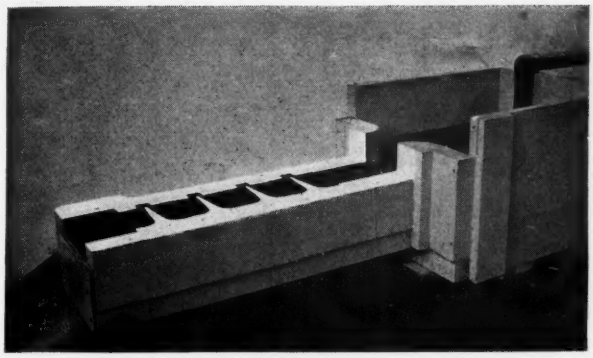


Fig. 6. The model tank used in the tests

shows that notwithstanding the enlarged grooves no fundamental changes in the flow can be observed. The current issuing from the throttle gap shoots again at first along the fins towards the bottom of the chamber and then downwards along the following wall. Along the wall opposite the chamber a very strong backflow streaming directly towards the first throttling gap is produced. The throttling action is accordingly perfect even in this case.

Figure 5 shows a working condition in which the shaft has been moved more to the right than the stationary carbon segments. At the same time it may happen that the shaft and its fins expand more in the radial direction than the casing, owing to greater heating up. This may be the case, for instance, during the warming up period, when an inclined surface is cut out of the carbon. As soon as normal working conditions have been attained, the flow shown in Fig. 5 prevails. In this case, also, a strong clockwise eddy exerting a vigorous damming action is created. Even with these deep and wide grooves hardly any influence on the throttling action can be observed. If, due to a difference in radial heat expansion, the fins should remain permanently somewhat displaced towards the bottom of the grooves, that is when the edges of the fins extend beyond the original carbon surface, no change will occur in the flow.

Stream issuing from the throttling gap always hits the flank of the groove and is, therefore, directed sharply upwards into the gland chamber. The axial

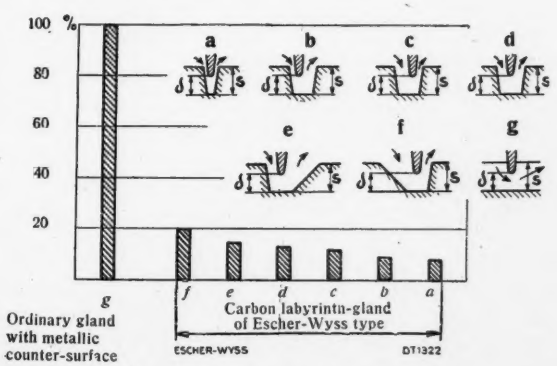


Fig. 7. Comparison of leakage through different gland shapes as shown by the small sketches. An ordinary gland, g, with metallic counter surface, is taken as 100 per cent

displacement, as assumed for Fig. 5, is rather large. In actual practice, especially in the case of high pressure glands where this new design is of greatest value, conditions are more favorable than shown in Figs. 4 and 5.

In case the shaft, in contra-distinction to Fig. 5 has been displaced more towards the left, the fins having expanded at the same time, gradually also in the radial direction, the leakage stream flows also in this case again from left to right. Owing to the new shape of the grooves with their inclined baffle surfaces, the leakage stream no longer flows along the fin, but is diverted across the chamber in a direction corresponding to the incline of the flank of a groove, and hits then the next fin. A strong current rotating counterclockwise is set up in the chamber. However, in contradistinction to Fig. 2 where the damming point, S, was near the edge of the fin, the leakage stream now hits the following fin at a much higher point and nearer to the bottom of the chamber; therefore the damming and baffling action and the destruction of the kinetic energy connected therewith, are also in this case, perfect.

Tests on labyrinth-glands with rotating and with stationary shafts show that the rotation of the shaft has practically no influence on the sealing properties of the gland. Therefore, in order to measure the quantity of leakage through the labyrinth, the same test with stationary shaft-fins was again carried out. Such a model test, in contradistinction to former tests with full-size glands, allows of an accurate illustration of the clearances being given.

Quantative Tests

In order to measure the quantity of leakage in dependence on the various clearances, a wooden model similar to the one used for the tests with water, was provided. This second experimental model was, however, closed at both ends and air, instead of water, was blown through. The loss of pressure and the quantity of air flowing through were determined by means of accurate nozzle measurements. The air, supplied by a fan, flowed from a container through a measuring nozzle and then passed into the first throttling chamber and from there, as shown in Figs. 2 to 5, through a number of labyrinths. The pressures in the several chambers were determined by accurate pressure gages, and by comparing the readings with one another one gets a good idea of the action of each chamber.

Figure 7 shows the ratios between various leakages for different types of labyrinths and with normal operating clearances. One can see clearly that the carbon labyrinth-gland is not at all sensitive and has much smaller leakages for all kinds of operating conditions than a gland with a hard stationary counter-surface.

The correctness of the facts ascertained by these model tests have been proved by the results obtained with many carbon labyrinth-glands fitted into steam turbines, compressors and steam circulating pumps. The tests described above explain why the carbon labyrinth-gland is practically insensitive to possible whipping of a shaft or other operating disturbances of a machine and why it ensures permanent and perfect seal without undesirable reaction upon the rotors.

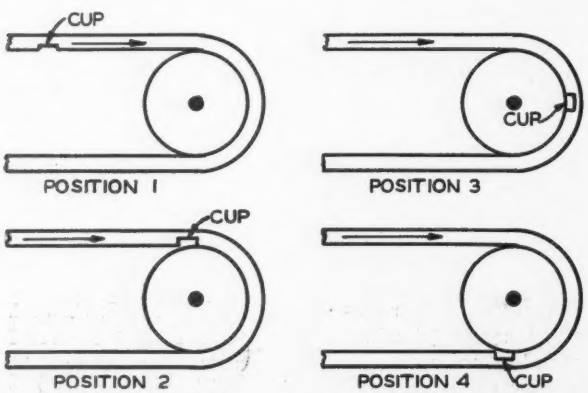
Readers' Conference

Holes and Cups in Power Plant Belts Belt with Vacuum Cup

EVERY NOW and then we hear or read the claim that a multitude of holes punched through a belt will increase the belt's pulling capacity. The claim is also made that holes cut "half way through" will serve as vacuum cups and will increase the belt's capacity.

Neither claim is true. Holes through a belt simply make the belt weaker and thereby reduce its capacity. The contact area is reduced slightly because where there are holes there certainly is no belt contact. Pulling capacity is proportional to the area of belt contact. It is claimed that holes are "air escapes" —a claim that has never been proven. Most important of all it has been proven that plain solid belts having no holes can outpull belts with holes. So let us dismiss the holes. Some hole enthusiasts also advocate drilling holes through the pulley rims so that solid belts can be used. That method, at least, does not reduce the capacity of the belt, but it is wrong both in theory and practice. Holes are of no assistance.

Let us analyze a belt having holes cut only half way through. It is claimed by advocates of that type of belt that a "vacuum" is formed in each and every "cup" and that the vacuum increases the belt's tractive power.



Herewith are four sketches showing a cross-sectional view of a single cup in a belt in four different positions. In Position 1 I have shown the cup approaching a pulley. The cup, of course, is full of air for the same reason that a passenger coach running at a velocity of a mile a minute, or faster, contains as much air as when it is standing still. When the cup is in Position 2 the action on the air in the cup is one of compression rather than suction. If holes punched clear through a belt permit air to escape, as is claimed, there would be slight compression of air in the cup, if anything. Then when Position 3 is reached the air will still be in compression, provided we have good contact between the belt and pulley. If contact is poor the slight excess amount of air will escape. But during the period of escape that excess air would hold a part of the surface of the belt away from the pulley, causing poor contact. Whatever occurs we can be sure that there is at least as much air in the cup in Position 3 as in Position 1. Lastly, in Position 4, just as the cup leaves the pulley, there can be no suction or vacuum because the cup is still filled with air. Cups, therefore, are of no assistance.

There is an automobile tread on the market which contains so-called "vacuum cups". That tire cannot be compared with a belt because a road is flat and tire is round. The area of contact is comparatively small and the rubber is probably compressed sufficiently to force some of the air out of the cup. It may be true that a vacuum is found. At any rate those tires are noisier than others and it is said that the noise is caused by suction between the tire and the road. The superiority of the vacuum tire has not been proven. On the other hand a belt is wrapped around the pulley. There is no appreciable compression, no vacuum, no suction. So, let us also dismiss the vacuum cup idea. First-class plain belts containing neither holes nor vacuum cups will pull more, will cost less, will last longer, and will be more satisfactory in every way. A good rule to bear in mind is: freak belts are generally inferior.

Newark, N. J. W. F. SCHAPHORST.

Blowoffs for Water Gages

WHEN danger of water gages clogging or pipes leading thereto exists, arrangement for blow-offs may be provided as follows:

When assembling, put a valve in the column water pipe line leading from boiler to the bottom of the gage. Instead of using an elbow to turn the water line upward to the bottom of the water gage, use a tee. Screw a short nipple into the lower end of the tee. Put a valve on the lower end of the nipple. A cutoff valve must be present in the steam line leading to the upper end of the water gage, and to the steam gage.

When it is desired to blow sediment out of the gage, first close the valve in the steam line leading to the top of the gage. Second, close the gage-glass valves if the steam pressure and heat are sufficient to endanger the gage glass. Third, partly open the valve below the tee, but not fully. Fourth, open the steam line valve slowly, opening or closing either of the valves until the desired result is obtained. This provides what may well be called a wet blowoff or blowout.

A dry (or steam) blowoff may be obtained as follows: First, close the valve in the water line leading to the bottom of the gage. Second, close the gage-glass valves. Third, open the valve below the tee (under the gage). Fourth, open the valve in the steam line; or if a wet-dry blowoff is desired, open the valve in the steam line before opening the valve below the tee. The latter method starts by blowing out the water first, following immediately with steam. These methods may be changed to suit individual requirements.

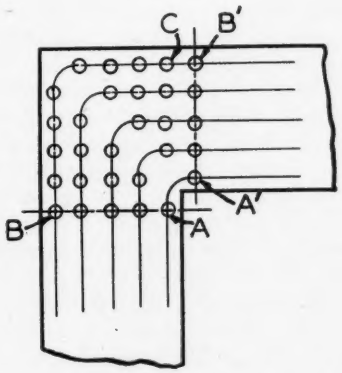
McCool, Miss. BUNYAN KENNEDY.

Bends in Air Duct

I WAS VERY much interested in the article appearing in the December issue on mechanical draft troubles by J. R. Darnell, which contains much valuable information, but I am not able to follow his explanation of the action of air in ducts at a 90 deg. bend.

Although I may not be able to offer a satisfactory explanation as to exactly what does occur, we may at least find that we have made a step in the right direction if we arrive at some conclusion as to what does not occur.

The enclosed sketch shows a duct elbow similar to that in Fig. 5 of Mr. Darnell's article, and he states correctly that in the case of marching men, the man at B, and the man at A, should come around in line to the points B′, and A′, before they start off in the new direction, but this would not occur in the case of a gas or fluid which filled the duct, where it would be more reasonable to assume that as the particle A, moved to A′, another particle C, would move to the position B′.



Assumed Paths of Gas Particles in 90-deg. Bend

From this it would appear that a reference to marching men does not throw much light on the problem.

Mr. Darnell states that the air particles at a 90 deg. bend, turn sharp, rather than on an arc, although it would not appear to be possible to observe the path of any individual particle of air. On the other hand, it is obvious that this would to a large extent be controlled by the shape of the duct bend, but I understand that Mr. Darnell means that the path of least resistance is a sharp turn, which seems to be borne out by experiments, but this does not answer the question as to why this should be so.

I think that the problem is one which would bear further discussion, as, although the effects of different bends appear to be fairly well understood, theories explaining the cause of these effects in a satisfactory manner, do not appear to be so readily available.

In connection with this, it will be well to keep in mind the fact that we are dealing with particles of air of very small size, and a ¼ in. radius would be very large in comparison with the diameter of a molecule. On the other hand, the large friction surface presented by the wall of a long radius bend might introduce considerable resistance.

Even if a bend is mathematically sharp, in all probability the compression of a cushion of air in the corner would cause it to react upon the air flow as if it had a small radius of sufficient length to afford an easy turn for the minute air particles.

It has often been assumed that air coming up to a sharp outside bend loses its velocity head, compresses and starts off again in another direction. There is no doubt that there must be some compression and re-expansion and this would cause a small energy loss, but more recent observations of the small loss occurring at sharp bends would indicate that the loss of velocity head at this point cannot be very great. Perhaps the answer lies in the fact that even the sharpest bends act as if they have sufficient effective radius to turn the molecules of air without greatly retarding their velocity.

JAMES O. G. GIBBONS.

Bloomfield, N. J.

Rubber Belt Made Over

IN SEPTEMBER, 1931, the Franklin Board & Paper Co., of Franklin, Ohio, installed a 101 ft. 40-in. 10-ply Goodrich Highflex belt on a Corliss engine drive. In the spring of 1936, after the belt had seen almost 5 yr. continuous service, it was deemed advisable to abandon the drive.

Examination showed the belt to be still in excellent condition and capable of many more months' operation. The belt was returned to the Goodrich plant where it was cut to 60 ft. length and 32-in. width, stripped down from 10 to 9 ply and then made endless by the Plylock splice. Upon completion of this work, the remodeled belt was installed on the 250 hp. drive, as shown in the accompanying illustration. It has now been in operation almost a year.

Conversion of belt over to this new drive resulted in little or no loss of material. The remaining 40 ft. of belt, as well as the strip left from the original cutting down operation, were cut into 6 and 8 in. widths and stripped to 4-ply for various transmission purposes about the plant.

Akron, O. R. W. SMITH.

Five-Year-Old Transmission Belt Remodeled to Meet Changing Drive Requirements

Oil Burners for Power Boilers

APROPOS Mr. Gibbons' comments in the December issue, page 730, on the amount of steam required by steam atomizing oil burners I wish to call attention to tests which I conducted back in 1923. Even at that time there were two burners on the market which averaged for atomization less than one per cent of the steam generated. Today, oil burners using steam for atomization should be even more efficient.

As shown by the table, three tests were conducted with each make of burner. Both were of the inside

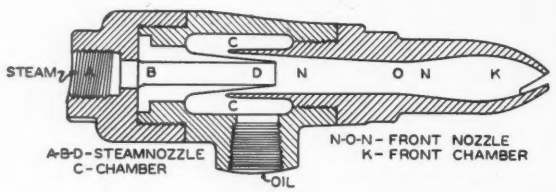


FIG. 1

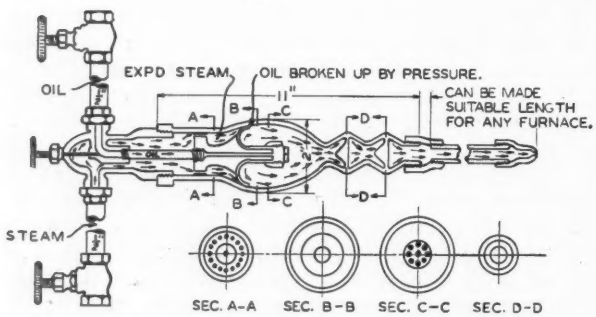


FIG. 2

Fig. 1. Simplicity of construction recommends this inside mixing, steam atomizing oil burner for dirty fuel oils

Fig. 2. Less than one per cent of the steam output is used by this burner for atomization but it is not suitable for dirty oil

mixing type as shown by Figs. 1 and 2. So far as their relative efficiencies in these tests were concerned there was little to choose between them. Each showed an average steam consumption of 0.127 lb. steam per lb. oil or 0.85 of one per cent of the steam output. Since the fuel oil used averaged about 16 deg. Be'. and contained considerable free carbon, burner X as shown in Fig. 1 proved the more satisfactory in daily operation as there was less trouble with this carbon causing clogging of the burner. When burner Y, as shown in Fig. 2, was used the orifices for admission of the oil, as shown in section A-A, became clogged with carbon after one day's operation while burner X would operate for several days without difficulty.

As shown in Fig. 3, the steam used for atomization was measured by means of an orifice manifold and mercury U-gage. By means of the latter the steam pressure differential on each side of the orifice could be read with accuracy. The initial pressure was measured by the spring gage mounted above.

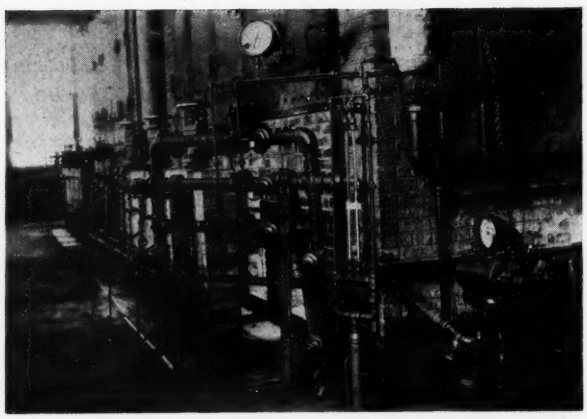


Fig. 3. Steam for atomization of fuel oil was measured by means of the orifice manifold and mercury U-gage. The meter at the right measured the oil

The orifice manifold was constructed of 2-in. pipe with each line provided with orifice plates made of 1/16-in. sheet iron. The orifices were ½ in., ⅝ in. and ¾ in. diameter respectively. One or more orifices were used so that the lower pressure always was somewhat greater than 58 per cent of the higher. The oil flow was measured by the meter shown at the right in Fig. 3. This was a positive displacement type of meter, suitable for heavy oil and was carefully calibrated before the tests. The boiler was not operated at any constant load but was used to meet changes in plant demand.

The steam flow was calculated by the following formula:

$$W = 1.9\,A\,K\,\sqrt{(P\text{-}d)\,d}$$

where,

W = lb. steam per min.
A = area of orifice in sq. in.
P = absolute initial pressure, lb. per sq. in.
d = difference in pressure between the two sides of the orifice, lb. per sq. in.
K = a constant, 0.63 for a square edged hole in a thin plate.

It has been my experience, based on actual tests, that steam atomizing oil burners give more satisfactory results with heavy, dirty oils than can be obtained with burners using mechanical atomization. Higher percentages of CO_2 can be obtained with steam and the overall efficiency is higher in spite of the fact that the steam slightly increases the chimney losses.

Evaporation Tests - Oil Firing With Rated 600 H. P. Boiler

Test No.	Gal. oil 60° F.	Pounds Oil	Pounds Steam for Atom.	Lb. Steam per Lb. Oil	Lb. Water Equiv. Evap.	Steam for atomiz. % output	Percent CO_2	Flue Gas Temp. °F.	Percent Effic.	Remarks
1	327	2644	332	.126	39241	0.85	13.8	572	76.3	Burner X
2	396	3288	337	.102	46653	0.72	13.2	637	73.0	" "
3	256	2028	311	.153	31787	0.98	13.9	550	80.6	" "
Av.	326	2653	327	.127	39227	0.85	13.6	586	76.6	" "
4	242	2048	280	.137	30130	0.93	12.4	515	75.7	Burner Y
5	362	2894	336	.117	42607	0.79	14.0	592	75.7	" "
6	271	2165	272	.126	33259	0.82	13.2	541	79.1	" "
Av.	292	2369	296	.127	35332	0.85	13.2	549	76.8	" "

In the series of tests recorded in Table 1, however, the loss due to the steam used for atomization averaged about one half of one per cent.

Chicago, Ill. J. R. DARNELL.

Calculated Combustion Temperature

EXPRESSION of formulas in print is frequently misleading. A formula for any purpose should be accompanied by a complete description of its suitable range of application or its limitations. It is for this reason that the article, entitled "Heat of Combustion Calculated from Fuel Analyses" on page 580 of the October, 1936, issue, invites comment.

In the first place, Dulong's Formula would be better if adapted to more recent heating values of the component elements in the following form:

$$\text{B.t.u.} = 14{,}150\ C + 61{,}000\ (H - 0/8) + 3890\ S$$

Even with these newer heating values a series of checks by respective comparison with reliable laboratory fuel analysis and calorimeter heating values of a typical eastern bituminous coal differed in some instances as much as 3 per cent.

The boiler-stack loss from the moisture and hydrogen in fuel is generally a relatively large item. For this loss the article gave the formula:

$$\text{B.t.u.} = 9H\ [(212 - t) + 970.4 + 0.46\ (T - 212)]$$

This expression would be correct if the water vapor in the flue gas has a pressure of 14.7 lb. per sq. in. abs. Unfortunately the partial pressure of the total water vapor in the flue gas is more like 1 lb. per sq. in. abs. when burning coal. Under this condition it would have a greater heat of superheat for a given stack temperature because its saturation temperature is nearer 100 deg. F. instead of 212 deg. F., and its latent heat would be nearer 1035 B.t.u. per lb. as against 970.4. With a fuel and flue gas analysis known the partial pressure of the total water vapor present in the flue gas may be calculated and the enthalpy or heat content at T and t read directly from steam tables. A very satisfactory empirical formula, however, for coal at least, involves less computation and has the form:

$$\text{B.t.u.} = 9H\ (1087 + 0.46\ T - t)$$

Calculations for this loss involving a typical eastern bituminous coal gave 550.7 B.t.u. per lb. of coal by the exact method using the partial pressure, 550.8 by this empirical formula, and 502.2 by the preceding formula. Thus, the formula given in the article of the October issue is 9 per cent in error, while the use of the above well-known formula results in a negligible error.

In conclusion, the formula given in the article for the theoretical flame temperature would be correct if "T" is interpreted as the temperature rise of the combustion gases and if the lower heating value of the fuel is used instead of the higher. The flame temperature would then be obtained by adding the temperature of the air supplied to the value of T obtained by that formula. This would be a sizable effect when preheated air is used. While it may be of interest to know the theoretical flame temperature for design purposes, it is questionable that any practical operating use could be made of it. The actual temperature attained depends chiefly upon the rate at which heat is absorbed from the gases in the furnace. This will not bear the same relation to the theoretical temperature among unlike furnaces nor even have a constant ratio in any one furnace at different boiler-steaming rates or at different excessive air percentages at the same fuel-burning rate.

Detroit, Mich. G. G. GUTHRIE.

Humanics

FOR OVER a year 11 men, all foremen of departments, had been sitting around the table with the manager as the head taking up what is called the study of the human being in the factory, toward the end we had nicknamed the study Humanics. The topics for the day are the job and the worker.

In hiring a person the old procedure is well known to all who have hired help of any sort. Sometimes we were fortunate, but often we had to let the person go because he was not fit for the job. So each one of us was required to place on a piece of paper what we thought was necessary for the applicant to know about the job when he applied for it: Title; duties, inside or outside; did it require continuous standing on one's feet in one place or walking around the factory; light or heavy work; eye strain or nerve racking; noisy, smoky and dusty, or damp; hot, cold or wet; clean or dirty; same thing all of the time or a change; fast or slow working conditions; was an experienced man hired or was there a training period required; hours, pay and how often paid; any promotion; did he have to bring his own tools or not. It becomes apparent that the job is a lot clearer to the applicant.

From the worker is required the following: Sex, age, and physical fitness; the applicant is required to pass a doctor's examination for physical fitness; how much of an education has he? The job may require reading, writing or dictating and copying, so the applicant is asked whether he is left or right handed. His habitual accuracy is ascertained as well as how much experience has he had.

With the above to aid a foreman, the chance of picking a wrong type is lessened. At least one has a pattern to go by.

New York, N. Y. G. T. MICHAELS.

Flexible Coupling Failure

A 50 H.P. direct current motor was connected to some mill shafting through a flexible coupling of the steel spring cushion type. A piece of the coupling broke off and got wedged between the faces of the coupling. This forced the two faces apart, the armature shaft was pushed sideways, fracturing the end plate, causing the armature to foul the pole shoes, damaging the windings and core, the field coils were badly damaged and the pole shoes distorted. This shows how a motor failure may be brought about by the failure of a flexible coupling. It is important that these latter are inspected at intervals so that any signs of wear or loosening are detected.

Sussex, England. W. E. WARNER.

Oil Burners for Power Boilers

I HAVE just read the article by James O. Gibbons, page 730 of the December 1936 issue of Power Plant Engineering titled "Oil Burners for Power Boilers," answering a communication of Mark Bell in the November issue, regarding the pros and cons of steam atomizing and mechanical pressure atomizing burners.

I am familiar with both mechanical and steam atomizing burners and am of the opinion that there is nothing a mechanical atomizing burner can do which cannot be easily duplicated by a steam atomizing burner, but that there are many things a steam atomizing burner can do which the mechanical atomizing burner cannot do.

The usual so-called wide-range mechanical atomizing burners have most of the weaknesses of ordinary mechanical atomizing burners, and in addition the following disadvantages:

a. Return to the storage tank of excessive quantities of hot oil, thereby building up temperature in the storage tank to a dangerous point with possible gassing of oil and loss of suction.

b. Heat loss from storage tank becomes excessive.

c. Steam used for pumping remains the same for low loads as for high loads—in fact, I have seen a modern mechanical atomizing system where the steam fuel pump actually speeds up when the fires are reduced, the governor endeavoring to maintain constant oil pressure.

d. Formation of soot and carbon when carrying low flame due to cooling of walls and floors.

It is true that wide-range mechanical burners can be operated for short periods of low flame following periods of high flame, and maintain a clean fire. If this is continued for any length of time, however, side walls and floor cool to such a point that they no longer radiate back into the flame the heat necessary to help flash the entering oil, resulting in a dirty, inefficient fire.

There are plants using these so-called wide-range mechanical burners that buy patented "soot destroyer" in large quantities endeavoring to keep tubes clean, especially where the night and week-end loads require a small flame over a long period of time.

I have just visited a plant where there are two 400-hp. straight tube w.t. boilers, set high for oil firing with three mechanical atomizing burners per furnace, natural draft for light loads, forced draft for heavy loads; maximum load 800 hp., approximately 240 gal. per hr., carried on one boiler. The average evaporation is approximately 10 lb. of water per lb. of oil. Night and week-end load is approximately 50 gal. per hr. when soot and carbon deposits are heavy. A steam atomoziing system would give 14½ to 15 lb. evaporation during the daytime and 12 to 13 lb. for the night load—an average of 13½ to 14 lb. per lb. of fuel. This dropping of efficiency at night is due to a higher proportion of radiation loss from boiler setting and is unavoidable, but a drop to 10 lb. as an average figure for day and night loads combined is inexcusable.

I have before me two CO_2 charts from another plant, where there is a 250-hp. Badenhausen boiler, set for oil firing, fired with mechanical atomizing burners of a well known make. One chart was made while the glass door of the CO_2 meter was covered over with paper, and fires adjusted by the eye. The average CO_2 is approximately 7 per cent; evaporation is given as 10.9 lb. water per lb. fuel; stack temperature approximately 520 deg. average.

The second chart was made with the chart visible to the fireman to help guide him in securing better combustion. The average CO_2 is about 10 per cent; evaporation is given at 11.8 lb. water per lb. fuel, and stack temperature about 500 deg. average.

Why wasn't the CO_2 maintained at 13 per cent or 14 per cent? This was a test. There was a real incentive to do the best possible. The CO_2 meter was checked, for on the savings depended the sale of the recorder. The answer is obvious. Ten per cent CO_2 is the best average that could be maintained without smoking or damage to brickwork or boiler.

Steam atomizing burners in this plant would easily develop 14.5 to 15 lb. water per lb. of oil, after deducting the atomizing steam, and without smoke, soot, carbon or damage to furnace or boiler.

I have before me another CO_2 chart which represents an ordinary day's run of a boiler plant in a large meat packing establishment in Newark, N. J., B. & W. boilers, fired with steam atomizing burners. The average CO_2 is 14 per cent. A 10-hr. test on these boilers showed an efficiency of 82.3 per cent with an evaporation of 15.95 lb. of water per lb. of oil.

Another CO_2 chart which I have taken from an ordinary day's run in a processing plant in New York City, where the boilers are fired with steam atomizing burners, average CO_2 of 13.5 per cent. These are low set boilers not at all ideally arranged for oil firing, yet the evaporation is close to 15 lb. of water per lb. of oil.

With the mechanical atomizing system fuel oil heaters producing a higher oil temperature, must be cleaned periodically. With the steam atomizing system a lower oil temperature is usual and heaters do not foul up unless carelessly set for a much higher temperature than required.

Cost of maintenance with a mechanical atomizing system is much higher than with the steam atomizing system in the same furnace. I have seen plants relining furnaces every 2 yr., which, with steam atomizing burners, would last from 5 to 7 yr. Maintenance of burner equipment is also heavier with mechanical atomizing equipment. Turbulators or diffusers are a continuous source of expense and if not replaced when damaged, will cause lowered efficiency. The same applies to burner tips, a worn orifice of which will adversely affect atomization and combustion.

Higher drafts are required with the mechanical atomizing system, which means higher first cost of stack or blower, maintenance of same, and continuous excessive infiltration losses.

I have seen numerous plants using mechanical atomizing equipment operating at less than 30,000 B.t.u. per cu. ft. heat liberation, which, under the instructions from the consulting engineer, limit their CO_2 to 10 per cent for fear of damage to brickwork and tubes. Steam atomizing burners will develop 13 per cent to 14½ per cent without such damage, under the same conditions. This is partly due to the ability to project the steam

atomizing flame and control its shape to prevent impingement. In other words, the three requirements of time, temperature and turbulence are fully met.

Guarantees of steam for atomizing of not more than 1 per cent are not uncommon. When it is considered that over a pound of water is released in the furnace for every pound of oil burned, due to the hydrogen in the oil, the slight additional amount used for atomizing can have no ill effects on the boiler or its setting. This 1 per cent expended for atomizing, creating turbulence, projecting the flame and controlling its shape is returned many times in better combustion and higher efficiency.

Why, if the above is true, are so many mechanical atomizing burners purchased? Usually because of exaggerated statements as to excessive steam consumption by steam atomizing burners; statements that the Navy Department uses only mechanical atomizing burners on all battleships and cruisers (they fail to say this is the only type they can use because fresh water is so precious at sea, and that they often use 15 or 20 burners per boiler; which would be a prohibitive expense for the ordinary stationary plant).

Mechanical atomizing burners usually look better because of the registers, although in the last few years this has been overcome, as registers are becoming quite common with steam atomizing burners. Extreme variations in steam demand and night and week-end load problems are avoided. Efficiencies are quoted only at maximum load. Also, there are many Navy trained men in charge of stationary plants whose training has been with mechanical atomizing burners only and who naturally are partial to that equipment.

Any engineer can theoretically prove that mechanical atomizing burners are more efficient than steam atomizing burners. Actually, it never works out. If it did, steam atomizing burners would have disappeared off the market long ago.

Steam atomizing burners are usually purchased when a man, not too theoretical in his engineering analysis, is willing not merely to look at a few plants, but to spend some time at each one and analyze the conditions as he finds them. Anyone closely examining furnaces fired by these two systems could not help but notice the marked difference between the two types of flame: the clear gaseous flame of the steam atomizing system and the heavy flaky flame of the mechanical atomizing system with its large proportion of "sparks" evidencing poor atomization.

All the above, of course, is based on a first-class burner and system, with proper furnace design and ordinary intelligent operation.

To my mind, there are only two disadvantages to a steam atomizing system: one is noise of operation—and this can be almost entirely overcome where necessary; and the second is that some means of starting must be provided where steam pressure is not maintained. This last objection is also overcome at a very slight cost of auxiliary equipment for preliminary firing.

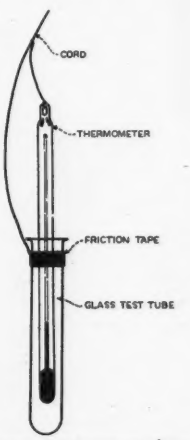
It would be instructive if you could secure and publish actual evaporation figures and CO_2 records from typical plants, using these two types of burners.

W. A. Horko,
Philadelphia, Pa. National Air Oil Burner Co.

Temperature Shield for Thermometer

The August, 1936, issue of Power Plant Engineering "Readers' Conference" carries an interesting article by Fred W. Schneider on "Bringing the Thermometer to Earth." This method is satisfactory only when there is little difference in temperature between the point where the thermometer hangs and the point to which it is lowered and read.

I have used a similar set-up, which is more accurate, for taking the temperature of cooling water in inaccessible locations. The dipping of a thermometer in the cooling water and pulling it out again for a reading would not be satisfactory because the thermometer reading would drop as soon as the thermometer left the hot bath.



Arrangement to prevent change in thermometer indication while being read

I successfully used a combination as shown in the accompanying sketch. An accurate laboratory thermometer was connected to an ordinary glass test tube as shown. The combination was dipped in the condenser water with the test tube empty. Upon immersion the test tube immediately filled with warm water and after the usual period of contact the thermometer registered the true temperature of the water. On pulling up the thermometer and tube full of water there was no drop in thermometer reading for several minutes because of the warm water bath surrounding the thermometer bulb.

This kind of arrangement was found suitable for taking all kinds of readings in inaccessible spots. With a little care the operator can avoid breakage. If necessary, a more rugged thermometer could be used and instead of a glass test tube a metal jacket could surround the bulb.

Philadelphia, Pa. L. H. Brandt.

Corrosion of Gears

An unusual case of gear corrosion recently came to my notice. The gears were situated in a damp place and were subjected to a heavy load. The corrosion was seen to be electrolytic due to the damp conditions and the varying stresses in the gears. In order to stop this corrosion, about 50 different lubricating greases were tried but the corrosion still continued.

Some of these greases had a graphite and some a lime base. A remedy was finally found by using a mineral grease to which 2 per cent of zinc oxide had been added.

A film of zinc oxide was soon deposited on the gear teeth by the grease. This was found to effectively stop any corrosion and at the same time give efficient lubrication.

Sussex, England. W. E. Warner.

New Equipment

Electric Counters

STRUTHERS DUNN, INC., of Philadelphia, have recently made available a new line of electric counters. These counters are vailable with five digits in either the reset or non-reset types.

The construction of the counters is such that the load on the operating mechanism is constant regardless of what number is being counted. This is accomplished by gearing the indicating wheels together, the same as is done in a watt hour meter. With this type of construction, an accurate and dependable counter has been developed.

The duty on the operating mechanism is practically the same as on a relay since the load is the same whether No. 1 or No. 10,000 is being counted. This eliminates any tendency for the counter to skip when only one or two wheels should be turning and miss when all of the wheels should be turning. Only one number appears on the dials at a time.

Overload and Circuit Protection for Electrical Equipment

A GREATER DEGREE of protection for electrical equipment is provided by the Re-Cirk-It Breaker developed by Heinemann Electric Co., Trenton, N. J. These fully magnetic and non-thermal units are available in instantaneous and time-delay types, any ampere rating from 50 milliamperes to 35 amp. and for circuits operating on just a few volts up to 250 v. d.c. or 460 v. a.c.

This breaker has a tumbler handle for switching current on and off. Ordinary breaker action is controlled by an hermetically sealed magnetic trip device. After opening on overload or short circuit the unit may be reclosed at once provided current has returned to normal. No resetting is necessary. The trip point is practically unaffected by ambient temperature and is immune to ordinary mechanical shock. It cannot be held closed against existing overload or short circuit.

"Stock-Bin-Lite" Reflector

A SPECIAL design reflector which effectively solves the problem of uniform lighting for bins, shelves and stacks in stock rooms, tool cribs and libraries has been developed by Benjamin Electric Mfg. Co., Des Plaines, Ill. These reflectors provide the uniform illumination from top to bottom of the tiers and the light into the interior of bins necessary for good seeing.

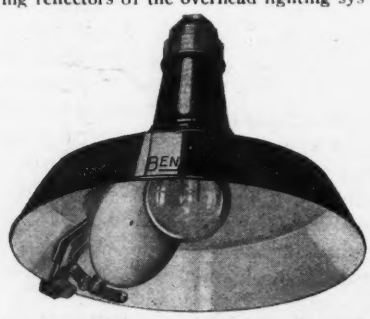
The deep, trough-shaped reflector directs maximum light downward to the bins near the floor, while the V-shaped deflector bar suspended below the reflector directs light upward above the cutoff of the reflector to light the topmost bins. The apertures in the end of the reflector allow light to pass which assists in building up illumination at points between units. Special care has been taken to properly shield the lamp filament from view when looking down the aisle and so minimize glare.

Reflectors are designed for installation in aisles of stock bins, where the width of the aisle is from three to four feet.

Reflectors are porcelain enameled steel, white inside, and out. Four types of hoods are availble, pendent, angle, feed-through and outlet box to provide for any mounting arrangement desired. Three sizes of reflectors are available for 60 watt, 75-100 watt and 150 watt lamps.

"Beam-Director" Attachment

A NEW accessory for lighting fixtures which makes it possible to convert existing reflectors of the overhead lighting system into supplementary lighting units without appreciably affecting their efficiency as general lighting units, has been developed by Benjamin Electric Mfg. Co., Des Plaines, Ill.

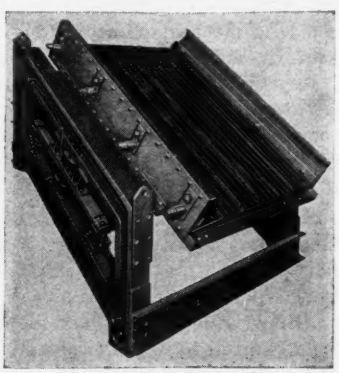


Benjamin "Beam-Directors" consist of simple, auxiliary projectors of etched Alzak aluminum which are quickly and easily attached inside the skirt of Benjamin RLM Dome reflectors. They are recommended for building up illumination over areas 30 to 36 in. in diameter on machines or work benches located within 10 or 12 ft. of the reflector to which they are attached. Under these conditions, they are capable of adding 10 to 15 foot candles more illumination than is provided by the general overhead lighting system alone. They are particularly effective in directing additional illumination onto shaded surfaces of machines or work benches to eliminate shadows cast by overhanging sections or other obstructions.

Available in two sizes, one to fit Benjamin RLM Dome reflectors for 200 watt lamps and one for RLM Dome reflectors for 300-500 watt lamps.

Electromagnetic Vibrating Screen

ALLIS-CHALMERS MFG. Co., Milwaukee, Wis., announces putting on the market a positive electro-magnetic vibrating screen using a new principle in which standard alternating current may be used without resorting to expensive auxiliary equipment such as motor generator sets. A new type of electro-magnetic vibrating motor, properly applied mechanically to the screen, gets its power for operation through a small rectifier mounted on the wall together with a small auto transformer and an amplitude adjusting switch for regulating the intensity of vibration.

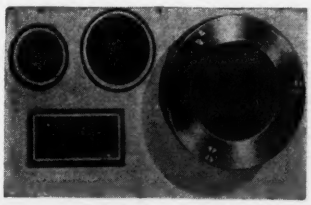


The use of dual magnets permits the magnetic forces to be applied equally in both directions which eliminates the necessity for storing energy by means of springs or similar devices. The rectifier splits the alternating current cycle into halves and delivers each successive half-wave or half-cycle respectively to the upper and lower magnets. The reciprocating motion is thus produced and transmitted to the screen without any revolving parts. The armatures do not touch the magnets in operation, as proper air gaps are provided, making the screen very quiet in operation.

This new "Utah" vibrating screen is particularly adapted for screens having openings of ½ in. or less, either wet or dry. Standard screens are made 25, 50 or 60 cycles, 440 v., the high frequencies being most satisfactory for fine screening. They may be had in open or closed types, with screens for different applications.

New Photo-Electric Element

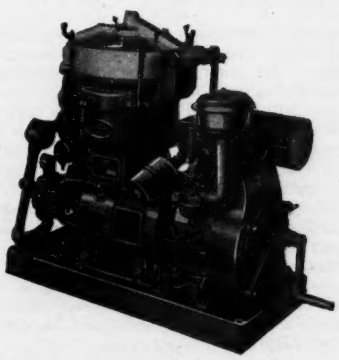
DR. F. LOEWENBERG, 10 E. 40th St., New York City, announces the development of a new dry disk self-generating photo-electric element commercially known as Electrocell. The operation of this device is based upon the fact that a potential is created between a semi-conductor and a conductor if one is deposited in a layer thin enough for light to penetrate and to strike the boundary plane. The radiant light energy is thereby directly transformed into electrical energy which may be used to drive current through an external load resistance. The Electrocell elements consist of a semi-conductive layer deposited on the surface of an iron disk and overlaid by a transparent conducting film. A coat of transparent lacquer is then applied over the entire treated surface with the exception of a narrow band near the edge where a metallic ring is sprayed. This ring serves as the negative terminal, while the untreated side of the iron disk forms the positive terminal.



The e.m.f. measurable across the terminals of the Electrocell elements on open circuit is practically independent of their size and shape. In direct sunlight, they generate an e.m.f. of 0.6 volt. The current obtainable from the element is a function of the illumination. At low light intensities the current is linearly proportional to the illumination. In strong light the current curves deviate from linearity and approach definite saturation values. These elements of standard quality are said not to vary by more than plus or minus 10 per cent. Closer tolerances of any specified degree are obtainable on order. Among the advantages claimed for them are rugged construction, unlimited life, perfect stability, ultra-sensitivity, uniform quality, response to all colors, and response to rapid light fluctuations. Their output for negligible resistance in the external circuit amounts to 480 micro-amperes per lumen. They are suitable to any surface where light is the operating force.

Engine Drives Purifier

DESIGNED PRIMARILY for purifying fuel or lubricating oil for diesel engines in isolated stations where electric power is not available, Goulds Pumps, Inc., Seneca Falls, N. Y., has just placed on the market a compact, efficient gasoline engine driven centrifugal purifier.

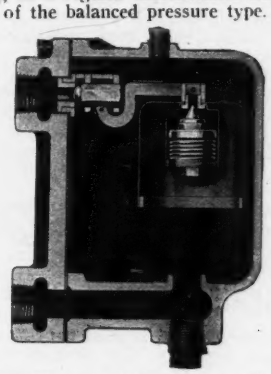


This consists of a standard series 300 Hydroil Purifier mounted on a drip type bedplate with a Briggs & Stratton 4 cycle engine driving it through a special patented slip type coupling. The unit will provide adequate purification of fuel oil in capacities up to 450 and lubricating oil up to 300 gal. per hr.

A prominent oil company of the Southwest is using one of these units on a truck for purifying fuel oil in batches at numerous diesel operated pumping stations.

New Sarco Bucket Trap

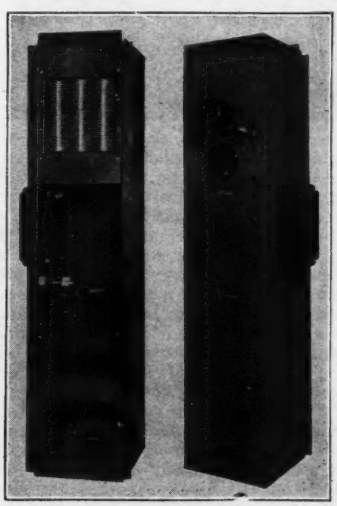
SARCO CO., INC., 183 Madison Avenue, New York, has added a new inverted bucket trap to its line of steam traps, employing the same sturdy, simple valve mechanism used in older designs. The trap can be furnished with integral air bypass carried inside the bucket and consisting of a regular thermostatic trap element of the balanced pressure type.



The bodies are of ample size and heavy design, and the traps are available in sizes ½ to 2 in. with bodies of cast iron for 125 lb., semi-steel to 250 lb., and cast steel up to 500 lb. steam pressure. Valve heads and seats in all types are of stainless steel.

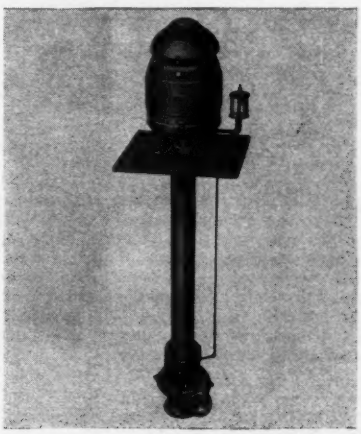
Dryer for Motors

ELECTROMODE RECIRCULATING DRYER, made by the Electric Air Heater Co. division of American Foundry Equipment Co. proved itself invaluable in drying out motor parts and other electrical equipment in cleaning up after the recent Ohio River flood by the Ohio Power Co. at Canton, Ohio. A housing 6 ft. long, 16 in. deep and 15 in. wide, containing the heating and circulating equipment may be bolted to the drying chamber. Heating units are aluminum grids cast around a calrod so that it becomes an integral part of the grid with no hot wires or dead air space. Temperatures up to 400 deg. F. are obtained by recirculation, the element requiring only 1 min. to attain full heat and temperature being held within 2 deg. of a desired point by thermostatic control.



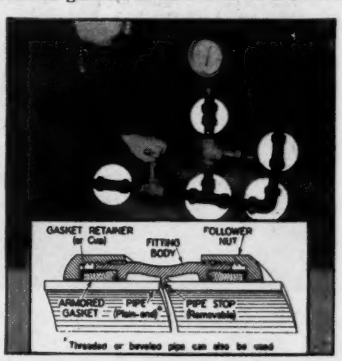
Sump Pumps

WORTHINGTON PUMP & MACHINERY CORP., Harrison, New Jersey, has announced the new application of their Freflo centrifugal pumps to underpass drainage. A simple catch basin or sump and an inexpensive housing are the only additional provisions required. Extra tanks, piping or valves are unnecessary. These centrifugals are made in capacities of 85 to 7,500 g.p.m. and may be equipped for automatic starting and stopping. They are built ready to install, with the foundation plate and driving head frame of heavy fabricated steel supporting the entire weight of the pump and driver.



Compression Pipe Fittings

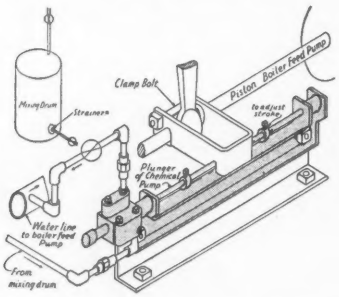
S. R. DRESSER MANUFACTURING CO., Bradford, Pa., is bringing out a standard line of Dresser Style 65 fittings in which, after inserting the plain-end pipe into the completely assembled fitting, it is only necessary to tighten two threaded octagonal follower nuts with a wrench. Resilient armored gaskets at each end of the fitting are compressed tightly around the pipe to form a seal, which Dresser engineers state is permanently tight, absorbs normal vibration, expansion and contraction and permits deflection of the pipe in the joint.



Pipe already threaded can also be joined in the same way. The complete line of these fittings includes, standard and extra-long couplings, tees, 45 and 90-deg. ells, for standard steel pipe sizes from ⅛ to 2 in., inclusive, black or galvanized.

Proportioners

CHEMICAL PUMPS and proportioners designed for use in connection with water conditioning systems have been developed and put on the mrket by Milton Roy, 2031 E. Madison St., Philadelphia. Pumps are made in two models, motor driven unit



type M.D. No. 100, complete with motor, and the rocker arm pump to be used with reciprocating type feed pumps. This type is made in three models: RA250, for use with horizontal feed pumps; RA300, for use with vertical feed pumps; and RA350, for pumping two fluids simultaneously. The pumps have ⅝ in. plungers, adjustable stroke, and ball check valves.

Circuit Breakers for Hazardous Locations

EQUIPMENT and circuit protection in hazardous locations where inflammable gases and explosive dusts prevail is provided by a special housing developed for its Re-Cirk-It Breakers by Heinemann Electric Co., Trenton, N. J. A two-part metal casting houses the circuit breaker in

place of the usual pressed steel cabinet. The circuit breaker is mounted on the upper section and is actuated by an approved bushed handle which closes and opens the circuit independently of the tripping action of the enclosed breaker when normal conditions prevail. The breaker is very accessible for wiring.

Station C to Be Enlarged

TO MEET GROWING demands for electric power in the East Bay Area, the Pacific Gas & Electric Co. will spend $5,250,000 in increasing its service facilities in that section. Work has already started on improvements at the Station C in Oakland, the company's central steam-electric generating plant at the East Bay Region, a standby unit.

Station C was built in 1909 and had 12,000 hp. capacity. This rating has been steadily increased and with completion of the current development in June, 1938, it will furnish more than 155,000 hp. Two additional turbo generators of the latest type are being built by General Electric Co.

To house the new installations the station building will be considerably enlarged. Additions will be made to the boiler room, and the pumping system is to be revamped and its capacity boosted from 110,000 to 140,000 g.p.m. A total of 500 ft. of 72-in. pipe will be added to the water circulating lines. Additional improvements include a new switchhouse, and a 110,000 v. cable from Station C to the company's substation at Park boulevard and First avenue.

Constituting the largest construction project of the company in some years, the entire job is scheduled for completion by June, 1938. The improved facilities will help furnish power for running trains across Bay Bridge and supply electric service to Golden Gate Exposition. It will greatly benefit industries in this area because the company will, as far as possible, carry out the "Buy at Home" policy.

Rotating-Cam Switches

A NEW LINE of rotating-cam switches, designed especially for built-in control applications and adaptable to a variety of electrical functions and machine requirements, has recently been placed on the market by the General Electric Company, Schenectady, N. Y. For non-built-in applications, the devices are available as

standard switches without the flanges used for flush-mounting on machines. Designated as G-E CR3300 rotating-cam switches, the new line is manufactured in a number of electrical and mechanical modifications making it universally adaptable to applications varying from machine-tool motor control to steel-mill master switching.

Two sizes are available—Size 0, rated 15 amp. continuous, and Size 1, rated 25 amp. continuous, both for 600 v. or less, alternating current. Four standard types are obtainable, as follows, for controlling: (1) single-speed motors for reversing application; (2) two-speed, separate-winding motors for non-reversing application, or for one speed forward and one speed reverse; (3) two-speed, single-winding motors for non-reversing application, or for one speed forward and one speed reverse; and (4) three- or four-speed motors for three or four speeds forward and one speed reverse. In addition, special sequences are obtainable and forms of the switches with off-position contacts are available. The switches can also be used as circuit-transfer switches.

Portable Meters

AIR METERS, draft gages, air filter gages and a Pitot static head for use with portable types are announced by Julien P. Friez & Sons, Inc. These new instruments are of clear bakelite with easy means for leveling, the graduated scale at the back being read through the bakelite, image of the liquid column being reflected on the polished scale surface. The Pitot head requires an opening only ½ in. diam. into a duct or housing and need not be held in exact opposition to the air stream in order to get accurate results. Types of meters cover velocities from 400 ft. a min. to 8000 ft. a min., and pressures from 0.005 in. of water vacuum up to 4 in. head. A convenient carrying case houses the portable instrument, tubes, fittings and a bottle of spare oil.

Bronze Valves

HANCOCK VALVE DIVISION of the Consolidated Ashcroft Hancock Company of Bridgeport, Conn., announce the completion of the 1¼, 1½ and 2 in. sizes in globe and angle patterns of their new line of bronze Hancock Valves. Smaller sizes were put on the market a year ago.

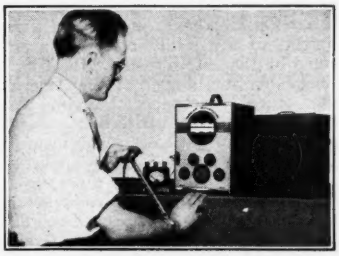
This new line of Hancock Valves is distinguished by the exceptionally hard stainless steel seats and discs with which they are equipped. The trim is heat treated to a hardness of 500 Brinell and then machined on a Diamond Boring Machine. The makers claim that this remarkable hardness enables these Valves to smash paper clips, nails, pipe turnings, boiler scale and sand without leaving a trace of a mark on either the Valve seats or discs. The illustration shows a steel nail crushed between the seat and disc of the 2 in. valve.

THE WESTINGHOUSE ELECTRIC and Mfg. Co. will move its Pittsburgh office and some of its general offices now located at East Pittsburgh to the Union National Bank Building in Pittsburgh. Occupying 9 floors of the building, from the fifth to the thirteenth floors, the Pittsburgh district office, subsidiary district offices and headquarters offices including executive, legal, industrial relations, sales and accounting departments, will be centrally located in the Union Bank Building to facilitate their operations.

Formerly the company's district office and subsidiary offices had been in this same building. The move will be made about May 1.

Crystal Vibration Pick-Up

So SENSITIVE it will pick-up the vibrations from the escapement of a wrist watch, yet so rugged it will withstand vibrations up to 1/16 in. amplitude, is a feature of the new Model 156 Sunco Inertia Type Crystal Vibration Pick-up recently developed by Sundt Engineering Co., 4238 Lincoln Ave., Chicago, Ill. The bimorph crystal used in the Model 156 is mounted inside of the aluminum case and has no direct mechanical connection with the prod. When the case (which weighs only 4 oz.) vibrates, the crystal flexes of its own inertia and sets up voltage impulses of exactly the same wave form as the mechanical motion. The response is practically linear up to the resonant frequency of 2,500 cycles. The output sensitivity is relatively high—2 v. R.M.S. with .001" motion at 400 cycles per sec. An 8" duralumin test prod is provided.



The Model 156 Pick-up is used in connection with the Model 150 Neobeam Oscilloscope, which has a built-in amplifier and a voltmeter on the output, to determine the frequency, amplitude, and velocity of vibration. Since the voltage output of the Model 156 varies as the square of the velocity and the vibration energy also varies as the square of the velocity, the voltage, as read from the output of the Neobeam Oscilloscope amplifier, is a direct function of the energy. In comparing very small vibrations, such as watches, etc., they are made audible with the speaker attachment shown in the illustration.

A partial list of applications on which vibration study with this set-up may be used includes: Production testing of electric motors, ball bearings, crankshafts, gear trains, fans, air conditioning equipment, and locating source of vibration in reciprocating or rotating machinery; checking relative smoothness of surfaces, such as paper, polished metal, gauges, glass plate, etc., checking longitudinal rods for fracture, and the relative efficiency of materials for deadening sound.

THE IDEAL COMMUTATOR DRESSER CO., 1033 Park Avenue, Sycamore, Ill., announce the acquisition of the Marshall Electric Co., of Elkhart, Ind., manufacturers of automatic regulators for voltage, current and speed control of electrical equipment.

Operations of the acquired company will be transferred as rapidly as possible to Sycamore and consolidated with the main office, production, engineering, research and development departments of the Ideal Commutator Dresser Co. The Marshall Electric Co. is an old, established concern, which occupies a leading position in the field of automatic voltage, current and speed control regulating equipment.

The Marshall regulator patents are all included in the purchase, and the Ideal Commutator Dresser Co. will continue to manufacture and develop the full line.

Thermal Overload Switch for Small Motors

A NEW THERMAL overload switch for fractional horsepower motors operating on line current and arranged for convenient mounting on the conduit or terminal box of the motor has recently been placed on the market by the General Electric Co., Schenectady, N. Y. Known as the Thermo-Tector, the device automatically disconnects the motor from the line when an overload occurs before the motor reaches a dangerous temperature, then when the motor has cooled it automatically reconnects it to the line. Where the automatic reset feature is not required a form of the new switch is available which can be used to disconnect the motor from the line and leave it disconnected until the device is manually reset. The Thermo-Tector is available in ratings for a.c. fractional horsepower motors having rated full load currents from 1.3 to 10.4 amps.

Kalamazoo Chief Engineers

AT THE FEBRUARY MEETING of the Kalamazoo (Mich.) Chief Engineers Club, T. P. Hetu of The Hartford Steam Boiler Inspection & Insurance Co., delivered a paper on modern trends in welded construction. Although welding has revolutionized construction practices in the power plant field it has introduced hazards which the engineers should not minimize.

Boilers produced under carefully controlled conditions by competent welders using highly developed welding producers are safe but unfortunately unfired pressure vessels must, in general, be looked upon with suspicion. Thousands of these, produced each year by welders without the necessary experience and ability to make sound welds, create a definite hazard to life and property.

Following the presentation of this paper the annual election of officers was held. Ralph Emmons, of the City Light & Water Plant, formerly vice-chairman, was elected chairman to succeed A. H. Peterson, of the Kalamazoo Vegetable Parchment Paper Co., Earl Dunton, of the Sutherland Paper Co. was elected vice-chairman and Arthur E. Woollam, local representative of Goulds Pumps, Inc., and Consolidated-Ashcroft-Hancock Co., was reelected secretary.

New 50,000 kw. "Top" for Essex

ORDERS HAVE BEEN PLACED by Public Service Electric & Gas Co. for a 50,000 kw. turbine-generator and two high pressure, high temperature steam boilers to be installed at the Essex Generating Station in Newark. This equipment will increase the station's generating capacity from 193,000 kw. to 243,000 kw. Boilers will be operated at 1,400 lb. pressure and at a temperature of 950 deg. F, the highest combined temperature and pressure ever to be utilized in a generating station in this country. The turbine-generator will be built by the General Electric Co. and the steam boilers by the Babcock & Wilcox Co. Boilers will be equipped to burn either oil or pulverized coal and each will have a capacity of 605,000 pounds of steam per hour.

The turbine-generator and boiler equipment will be installed in a section of the present boiler room. To provide the necessary space, 8 of the present 24 boilers will be removed and a section of the roof raised.

The use of high pressure, high temperature generating equipment in conjunction with the low pressure boilers and turbines now in service at Essex Generating Station is similar to the method used by the company to enlarge and improve the efficiency of its Burlington Generating Station several years ago. Known technically as a "superposed" installation, operation is as follows: Steam generated at high temperature and high pressure is reduced in passing through a high pressure turbine and exhausted into the existing main steam line operating at a pressure of 225 pounds, which supplies steam to the turbines now in operation at the station. The superposing of the new high pressure and high temperature equipment on that which is now installed will materially improve the efficiency of Essex Generating Station.

The turbine-generator will be the second largest unit in the Public Service system. A larger unit of 75,000 kilowatt capacity was installed in the company's Kearny Station during 1932.

It is expected the equipment will be ready for operation in the spring of 1938.

Elihu Thomson Dies at 83

PROFESSOR ELIHU THOMSON, 83, dean of American scientists, and one of the founders of the General Electric Company, died at his home in Swampscott, Mass., March 13. He had been seriously ill since January. Professor Thomson, together with Thomas A. Edison, James J. Wood, and Charles F. Brush were the great quartet which created the modern electrical industry. Funeral services were conducted in Lynn, Mass.

Elihu Thomson was one of America's greatest pioneers in the field of electrical science. His technical work was directly reflected in practical developments, as he was one of the most far-sighted of the early arc-light inventors, and experimented with the principle of alternating-current transmission far in advance of commercial demands. He held upward of 700 patents in the United States alone.

He originated the resistance method of electric welding, which has been in continuous use from 1887 to the present time; developed the repulsion type of induction electric motor; invented the magnetic blow-out principle in lightning arresters and electric switches, the oil-cooled type of transformer, the constant-current transformer, and the modern process of commercially treating fused quartz.

Professor Thomson's name was given to the Thomson-Houston Electric Company, organized in 1883, and merged in 1892 with the Edison General Electric Company to form the General Electric Company of today. He has ever since been associated with General Electric and at the time of his death was dean of that company's staff of scientists. For more than 15 yr. he was director of the Thomson Research Laboratory, located at the River Works of the Company at West Lynn, Mass.

There was scarcely any aspect of electrical science in which Thomson had not been active at some time or another. He originated the three-phase electric dynamo machine in 1879 and invented the first practical wattmeter, thereby winning half of the grand prize offered at the close of the Paris electrical exposition of 1889.

Outside of electrical matter he was also active. He invented the centrifugal cream separator and the centrifuge, an instrument now universally used in biological laboratories. He also devised the fluid pressure engine and the fused quartz mirror for

astronomical telescopes. On this latter development he made many important contributions.

His life-time hobby was astronomy, in which he was active as an amateur at an early age. He was also interested in microscopes, auto-chrome photography, and in building and playing pipe organs. He had a host of friends in scientific and engineering circles, not only in America but in Europe, particularly in England, the land of his birth.

Professor Thomson was the only man who ever received all three of England's highest scientific honors—the Hughes, the Lord Kelvin, and the Faraday medals. He also had the medal of the Verein Deutscher Ingenieure, outstanding German engineering award, the John Fritz medal from the four leading American engineering societies, and the medals of the Franklin Institute, the American Academy of Arts and Sciences and the American Institute of Electrical Engineers. He was president of the International Electrical Congress in 1904, and the president of the Electrochemical Congress in 1910 and 1911. At one time he was vice president of the American Academy of Arts and Sciences and vice president of the American Philosophical Society. He belonged to innumerable engineering societies all over the world.

Willis Lawrence

THE PASSING on January 9 last of Willis Lawrence, Mechanical Engineer of the Motive Power Department of the Interborough Rapid Transit Co., New York city, brings to a close a life spent in the betterment of power generation.

Mr. Lawrence, a descendant of Revolutionary and Puritan forbears, was born in 1868 at the old Lawrence home in Cold Springs, New York. For 5 yr. of his younger life he worked on neighboring farms, but his natural mechanical ability soon manifested itself and he secured a job in a large stone crushing plant at Storm King, 2 mi. away. He rose rapidly from oiler to machinist, then to engineer and finally foreman of repairs. Later, he refused the position of chief engineer and went to Weehawken, New Jersey, in 1890 to assist in the construction of another

large crusher plant of which he became chief engineer when it was completed.

In 1894 the ice making field seemed to offer big possibilities so Mr. Lawrence went with the New York Ice Co. Here he was appointed assistant engineer; later he became chief engineer. He remained with that company until January, 1902.

Shortly prior to this time Edwin Reynolds had been hurriedly called upon by the Interborough Rapid Transit Co. to design for it the engines which will forever remain famous, not only as the Manhattan type, but as those which, like the giant redwoods of California, were the last of their kind. Here in this new field, in a plant where all the great advances in the power house art were being for the first time applied, Mr. Lawrence was employed as a machinist and assistant operating engineer. In less than a year he became first assistant mechanical engineer. In May, 1904, he was made mechanical engineer; 3 yr. later he was given the position of mechanical engineer of both the Manhattan and Subway power houses.

All of Mr. Lawrence's intimate associates fully appreciate the conscientious and hard work done by him to accomplish his ends. Few people can realize the immense amount of detailed labor necessary to keep such two huge power plants in proper operating condition.

A. I. E. E. Nominates Officers

THE NATIONAL NOMINATING COMMITTEE of the American Institute of Electrical Engineers, consisting of members from various parts of the country, have nominated the following candidates for offices becoming vacant August 1, 1937.

For President: W. H. Harrison, assistant vice-president, department of operation and engineering, American Telephone & Telegraph Co., New York, N. Y.

For Vice-Presidents: Middle Eastern District, I. Melville Stein, director of research, Leeds & Northrup Co., Philadelphia, Pa. Southern District, Edwin D. Wood, general superintendent, Louisville Gas & Electric Co., Louisville, Ky. North Central District, L. N. McClellan, chief electrical engineer, U. S. Bureau of Reclamation, Denver, Colo. Pacific District, J. P. Jollyman, hydroelectric and transmission engineer, Pacific Gas & Electric Co., San Francisco, Calif. Canadian District, M. J. McHenry, manager, Toronto District, Canadian General Electric Co., Ltd., Toronto, Ont., Canada. The following directors were nominated: C. R. Beardsley, general superintendent of distribution construction, Brooklyn Edison Co., Inc., Brooklyn, N. Y.; V. Bush, vice-president and dean of engineering, Massachusetts Institute of Technology, Cambridge, Mass.; F. H. Lane, manager, engineering division, Public Utility Engineering & Service Corp., Chicago. For National Treasurer, W. I. Slichter, professor of electrical engineering, Columbia University, New York, N. Y.

William Henry Harrison, the nominee for president, was graduated from the industrial electrical engineering course at Pratt Institute in 1915. Before that he was employed by the New York Telephone Co. since 1909. His work until 1915 included apparatus inspection, assembling and wiring. Between 1915 and 1919 he was engaged in telephone circuit design with the Western Electric Company in its engineering department. In 1919 he became a member of the engineering staff of the American Telephone & Telegraph Co. and in 1924 was made equipment and building engineer with general supervision of the engineering of subscribers' station and central office plant of the Bell System. In 1929 Mr. Harrison became plant engineer with broadened responsibilities covering the general direction of the engineering, design and layout of all phases of the Bell System plant. In 1933 he was elected vice-president in charge of operations of the Bell Telephone Co. of Pennsylvania and the Diamond State Telephone Company of Delaware. In 1937 he was appointed assistant vice-president, department of operation and engineering, American Telephone & Telegraph Co. He became an associate of the Institute in 1920, a member in 1930, and a Fellow in 1931.

Recent Awards

THE 1936 LAMME MEDAL of the American Institute of Electrical Engineers has been awarded to Dr. Frank Conrad, assistant chief engineer, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., for his pioneering and basic developments in the fields of electrical metering and protective systems. The medal and certificate will be presented to him at the annual summer convention of the Institute, which is to be held at Milwaukee, Wis., June 21-25, 1937.

DR. W. D. COOLIDGE and Dr. Irving Langmuir, director and associate director respectively of General Electric's Research Laboratory in Schenectady, and Dr. Evarts A. Graham of the School of Medicine of Washington University in St. Louis, were recipients of the John Scott 1937 awards granted by the City Trusts of the City of Philadelphia at a dinner of the American Philosophical Society there March 5. With each award went a certificate, a copper medal, and $1000 in cash. The award to Dr. Coolidge was based on his application of a new principle in X-ray tubes; to Dr. Langmuir for his physical and chemical discoveries resulting in improved gas-filled incandescent lamps; and to Dr. Graham for his application of the X-ray to the study and diagnosis of gall bladder conditions. Ernest I. Trigg, chairman of the Board of City Trusts, made the presentations.

RIVER BEND STEAM STATION of the Duke Power Co. of Charlotte, N. C., is installing an additional 55,000 kw. generating unit to supplement the two present 55,000 kw. units. This will be a 650 lb., 825 deg. F. Westinghouse unit designed for four stages of bleeding. Steam will be furnished by two 275,000 lb. per hr. Combustion boilers, fired by pulverized fuel. The original River Bend, built in 1929, was included in the Dec. 15 Review issue of POWER PLANT ENGINEERING that year. The original steam conditions were 440 lb., 725 deg. F.

CONTRACT has been awarded to The York Ice Machinery Corp., York, Penna., to install in the new Capitol Power Plant Building, Washington, D. C., the world's largest refrigerating plant for air conditioning purposes. The amount of the contract is $642,284, according to S. E. Lauer, Vice-President and General Sales Manager of the Corporation. 6000 hp. is required to operate the system, which will supply 11,500,000 gal. of chilled water daily through approximately one mile of underground pipe line to air condition the Capitol, Senate Office Building, and the new and old House of Representatives Office Buildings.

CLEVELAND ELECTRIC ILLUMINATING CO. has started construction for the installation of an additional 50,000 kw. turbogenerator in the Ashtabula power plant. The new unit is practically a duplicate of the three now in service and will be installed in space provided in the present building. No new boilers will be added. Ashtabula Station, put in service in 1930 with three 50,000 kw. units was described on page 122 of the Jan. 15, 1931 issue of POWER PLANT ENGINEERING. The fourth generator will make this station the largest on the company's system.

News from the Field

UNIVERSITY OF ILLINOIS will hold its fourth short course on Coal Utilization, May 25 to 27 at Urbana, Ill. Detailed program may be obtained from D. R. Mitchell, 212 Transportation Bldg., Univ. of Ill. at Urbana.

FRANK J. ENRIGHT has resigned his position as advertising manager of Metal Progress and the American Society for Metals and, as announced by A. F. Holden has joined the A. F. Holden Co. of New Haven, Conn., as director of sales and advertising.

H. P. MEE, vice-president of Caterpillar Tractor Co., announces the appointment of E. R. ("Ed") Galvin as General Sales Manager of the company. Mr. Galvin left his position as general sales manager of Cleveland Tractor Co. in 1928 to become a district representative for Caterpillar, contacting in the field a small group of the Company's dealers. Shortly thereafter he became sales manager in charge of the eastern sales division, with headquarters at Peoria, and in January, 1936, was appointed assistant general sales manager, from which position the new appointment is a further step of advancement. Mr. Mee relinquishes the direct supervision of the sales department for the broader duties of directing all sales, service and advertising activities, and to assist more fully in general company administration matters.

UNDER THE DIRECTION of the National Research Council, Division of Engineering and Industrial Research, an inspection travel tour to European research laboratories is being arranged. The group will sail from New York on May 14 on the S. S. Champlain. The tour will be under the direction of Maurice Holland and additional information may be obtained from the Council Headquarters at 29 W. 39th St., New York City.

R. B. RENNER, who has been with the Jeffrey Mfg. Co. for the last 30 yr. as mechanical engineer, was recently made chairman of the executive committee of the materials handling division of the American Society of Mechanical Engineers. The function of this division of the Society is to spot, coördinate and bring before the engineering public outstanding developments in conveying machinery and its use.

FOSTER WHEELER CORP. has announced the appointment of Howard B. Hall as Regional Director in charge of its Cleveland, Cincinnati and Pittsburgh territories. Mr. Hall assumed his duties on March 1, and he will make his headquarters in the Cleveland office of the corporation at 526 Superior Ave. For the last 8 yr. Mr. Hall has been associated with Murray and Flood, Consulting Engineers. His industrial activities have brought him in close contacts with problems in heat exchange, compressed air, pumps and industrial oil burners.

FRICK CO., Waynesboro, Pa., announces the election of W. H. Aubrey as a vice-president of the company. Mr. Aubrey has been sales manager of the ice and refrigerating machinery department of Frick Co. since 1932. He continues in that capacity in addition to now being an official of the company.

THE LINCOLN ELECTRIC CO., Cleveland, has appointed John S. Humble as arc welding consultant for its Boston office, 10 High Street, for consultation on any question or problem about welding. Mr. Humble's work will be under the supervision of J. E. Raney, who is in charge of the Boston office.

DANIEL J. SAUNDERS has been promoted to Manager of Industrial Sales for The Permutit Co., New York, having been with the company for 17 yr. and recently Assistant Manager of Industrial Sales.

THE OSTER MANUFACTURING CO. of Cleveland, Ohio, announces the appointment of the following new officers: R. B. Tewksbury, chairman of the board; Roger Tewksbury, president and treasurer; Arthur S. Gould, vice-president, and Harry A. Maurer, secretary. The first three named, formerly acted in the capacities of president, vice-president and secretary respectively, while Mr. Maurer was general superintendent of the company's plants at Erie, Pa., and Cleveland, Ohio.

BLAW-KNOX CO. has recently announced the selection of H. B. Loxterman as vice-president and Albert L. Cuff as secretary of the company. Other officers announced are W. H. Eisenbeis as vice-president of the Union Steel Casting Co. and John Baker as sales manager of the Union Steel Casting Co. P. M. Fleming has been made vice-president and a director of the Pittsburgh Rolls Corp.

PUBLIC SERVICE ELECTRIC & GAS CO., Newark, N. J., has announced the promotion of Frederick P. Fairchild to be chief engineer, in the company's electric engineering department, succeeding Edward B. Meyer, who died January 30. Mr. Fairchild has been assistant chief engineer, electric engineering department, since November 1, last year. Prior to that he was mechanical engineer in the same department. He has had a varied experience in the engineering field with Stone & Webster, Dwight P. Robinson & Co. and other companies, including 7 yr. with United Engineers & Constructors, Inc. Mr. Fairchild graduated from the University of Kansas in 1910.

ANNOUNCEMENT is made by Koppers Co. that W. F. Perkins, vice-president in charge of the American Hammered Piston Ring and Bartlett Hayward Divisions of Koppers Co. and its subsidiary, The Maryland Drydock Co., all in Baltimore, Md., also has been placed in complete charge of the company's Western Gas Division in Fort Wayne, Ind., which supplies the public works and manufactured gas fields. R. A. Wickes will continue as general manager of the division under Mr. Perkins.

CRANE CO. has announced that on March 1, 1937, J. A. Dwyer, formerly manager of the Philadelphia branch, became district manager of all Crane branches in the Eastern territory, including all of the New England states, in addition to metropolitan New York, Eastern Pennsylvania, New Jersey, Maryland, and the District of Columbia. A total of eighteen Crane establishments thus come under the jurisdiction of Mr. Dwyer, whose headquarters will be at the company's New York branch.

ANNOUNCEMENT is made of the appointment of James Robertson Co., Ltd., as exclusive distributors of Link-Belt automatic coal burners in Canada, with headquarters in Montreal, and branches in Toronto, St. John, Winnipeg, and Saskatoon. The Link-Belt burner is manufactured in sizes from domestic units to stokers of 300-hp. capacity.

SALES OF Cochrane equipment in the New England territory have been consolidated under the Cochrane Steam Specialty Co., 80 Federal Street, Boston, Mass., O. S. Pike directing the sale of Cochrane water treatment equipment, while T. N. Graser will direct the sale of Cochrane specialties and meters.

HENRY P. HAHN has recently become a member of the engineering staff of the Crosby Steam Gage and Valve Co., New York. Mr. Hahn was attached for many years to the engineering staff of the Crane Co., and for the past five years has been chief engineer of the oil and refining department of the Société Anonyme des Établissements Jules Cocard, Paris, France.

EDWARD J. FERTIG has joined the New York Office of The Paul B. Huyette Co., Inc., located at 205 E. 42nd Street, as a sales engineer, specializing in the field of combustion control equipment.

C. O. BARTLETT & SNOW CO., Cleveland, Ohio, has announced the appointment of Lloyd R. Leatherman to represent the company's coal and ash-handling equipment in the Michigan territory, with office at 2140 Book Building, Detroit, Michigan.

NEW DISTRICT sales office has been established at Indianapolis, Ind., by The American Rolling Mill Co. of Middletown, Ohio, located in the Circle Tower. Austin Edwards, for many years associated with the Middletown sales district, has been named manager of the new Indianapolis district which will embrace a large section of Indiana.

THE FOXBORO CO. has announced the change of address of its Atlanta office on March 1st to Room 715, 101 Marietta Street Building, Atlanta, Ga., in larger quarters necessitated by the rapid growth of business in the Southern district.

AUSTIN CO. has completed erection of new research laboratories for The American Rolling Mill Co. at Middletown, Ohio, welded steel framework, with porcelain enamel exterior panels and large areas of glass block, providing more than 100 air-conditioned rooms for laboratories, shops and offices, with total area of 43,500 sq. ft. Roof deck is perforated steel. Cost, exclusive of equipment, was about $260,000.

HOMESTEAD VALVE MANUFACTURING CO. has announced that Elliott G. Johnson has returned to the company to take over his old duties as Advertising Manager, after a four-year leave of absence, during which he was serving the Government as Ordnance Engineer with the Navy. A background of mechanical engineering received at Carnegie Institute of Technology, and early training at Westinghouse Electric & Mfg. Co., prepared Mr. Johnson for his work in the industrial advertising field.

Improved Portable Balancing Equipment

THE ELECTROCON CORP., 6 Varick Street, New York, has announced several improvements in the design of the Davey Portable Balancing Equipment.

The illustration shows the complete Equipment for Power Plants. This is suitable for the balancing of large turbines and also for auxiliary machines such as fans, exhausters, pumps and motors. In addition, the photographic feature of the "two-direction" Vibrometer enables records of turbine vibration to be made periodically, which is often the means of discovering troubles before they become serious.

The Model-S2, Vibrometer, which measures in two directions simultaneously and also indicates wave form, is shown at the right of the illustration and the "single-direction" model-1, Vibrometer is in the center. These two Vibrometers may be used interchangeably.

The Model-3, Stroboscopic Lamp with three neon tubes is shown at the left.

In the left foreground, the Breaker Head and phase adjuster is shown coupled to the Synchronous Motor Unit. This Synchronous Motor Unit is a new feature used for balancing 60-cycle machines running at 3600, 1800 or 1200 r.p.m. By its use, it is unnecessary to couple the Breaker Head to the shaft of the machine and the Motor and Breaker Head may be placed at any point most convenient to the operator. For machines running at other speeds, the Breaker Head is driven from the end of the shaft by a tachometer point.

A NEW LINE OF round and rectangular design miniature instruments available in alternating-current, direct-current, rectox and radio-frequency types has been announced by the Westinghouse Electric and Manufacturing Company. For use as ammeters, milliammeters, microammeters, voltmeters, millivoltmeters, power level meters and volt-ohmmeters this line of Type 35 miniature meters are accurate, durable and easily read.

ANNOUNCEMENT has been made of an agreement for the acquisition of the complete line of pneumatic controls manufactured by the National Regulator Co. of Chicago, by the Minneapolis-Honeywell Regulator Co., Minneapolis, Minn. Minneapolis-Honeywell was established in 1885, while the National Regulator Co. was formed 35 yr. ago. As a result of this acquisition, the heating, ventilating and air conditioning industry and the collaborating professions will have available from one reliable source a full range of both pneumatic and electric controls and control systems.

WHAT IS SAID TO BE the largest air conditioning installation in the southwest was recently contracted for by Waite Phillips, owner of the Philtower and Philcade Bldgs., Tulsa, Okla. Both buildings will be air conditioned from a central plant by means of cold water. The Frick Co. of Waynesboro, Pa., is supplying four large ammonia compressors, complete with two condensers and a shell and tube water cooler, for this unusual job which will involve about 900 tons of refrigeration. The Philtower building was built in 1928, and was described on page 484 of the April 15, 1929, issue, and the Philcade building was built 2 years later.

JEFFREY MANUFACTURING CO. of Columbus, Ohio, announces a protected screw takeup for conveyors and elevators, having a U-shaped shield over the entire screw with bronze nut so cored out that it slides freely over the shield. After adjustment to the proper tension, the bearing is rigidly clamped to the frame, thus relieving the screw of all strains due to operation of the machinery.

N. B. GILLILAND has been appointed by The Lincoln Electric Co. to the sales engineering staff in its Detroit office, 2457 Woodward Ave. He has a background of 3½ yr. university training and a year of instruction in welding. With J. M. Robinson, manager of the office, Mr. Gilliland will be associated with C. H. Buckmaster, J. F. Cunningham and T. A. Steel.

HOME STUDY COURSES, covering a wide range of business and engineering subjects, are listed in a recent issue of Extension News, issued by Pennsylvania State College, State College, Pa.

BURLINGTON INSTRUMENT CORP., Burlington, Iowa, announces that Diesel Plant Specialties Co., Chicago, Ill., will act as its middle west representatives and distributors of Burlington Voltage Regulators; also the appointment of the Commercial Engineering Co., Inc., Washington, D. C., as representatives.

THE RELIANCE GAUGE COLUMN CO., Cleveland, O., announces the following additional firms as representatives in their respective localities: The Chas. M. Setzer Co., of Charlotte, N. C., throughout North and South Carolina; Eshelman & Potter, of Birmingham, Ala., throughout Alabama and Tennessee, and T. C. Messplay of Kansas City, Mo., in western Missouri and the state of Kansas.

EFFECTIVE JANUARY 1, 1937, the business of the Canton Forge & Axle Works, 2025 Dueber Ave., S. W., Canton, Ohio, has been a wholly owned subsidiary of Poor & Co., but will continue to operate as heretofore with no change in management or personnel.

FOOTE BROS. GEAR AND MACHINE CORP. announces the following changes in territorial sales personnel: E. G. Akridge who has been handling the territory on the north side of Chicago is appointed direct factory representative in the Detroit territory succeeding Thomas Lord, resigned. F. A. Emmons, Jr., takes over the territory vacated by Mr. Akridge and Harry Harrison has been appointed sales engineer in the Central territory in Chicago.

DAN S. HELMICK, Joseph V. Edeskuty and Richard E. Lutz, all well known in the middle western industrial power plant field, recently announced the formation of a new organization to carry on a general engineering practice under the name of Helmick, Edeskuty and Lutz with headquarters in the Essex Bldg., Minneapolis, Minn.

AT A MEETING of the board of directors of the Westinghouse Electric & Manufacturing Co., held in New York, C. W. Pomeroy was elected secretary of the company to fill the vacancy left by the death of Warren H. Jones.

ROBERT F. VOGT, Allis-Chalmers Mfg. Co., assistant chief consulting engineer since 1921, has been appointed chief consulting engineer, to succeed the late J. F. Max Patitz. Mr. Vogt is a graduate of the Swiss Polytechnicum at Zurich, where he was a pupil of Dr. A. Stodola. His professional career began in the United States in 1903. He has been connected with Allis-Chalmers since 1907, entering as mechanical engineer, and has been connected with many activities relative to the design and development of sundry equipment of various departments.

WARREN HOWLAND JONES, secretary, assistant treasurer and director of the Westinghouse Electric & Manufacturing Co., died of pneumonia recently at Mount Vernon Hospital, in Mount Vernon. He was 61 years old and lived in Mount Vernon at 51 Sycamore Ave. His wife survives.

For the Engineer's Library

THERMODYNAMICS. By J. E. Emswiler. 6 by 8 in., 350 pages, 162 illustrations. Fourth edition. Cloth, $3. McGraw-Hill Book Co., Inc., New York City.

In this edition, new material is incorporated on water-vapor refrigeration, on the steam-air mixture, both as applied to air conditioning problems; treatment of the psychrometric chart and its uses has been amplified and the discussion on energy laws has been emphasized. As in previous editions, sources of energy, action of heat engines, properties and heat interchanges of steam, losses in heat transformations and the action on various cycles has been covered. A chapter deals with refrigeration cycles and the action of compressors, absorbers, condensers and refrigerant expansion.

Action of gases in heat interchange, as in combustion engines and air compressors is the subject of three chapters and a fourth chapter takes up gas and vapor mixtures and their action as in air conditioning. Action of the air heat engine takes up one chapter. Two chapters deal at length with energy laws, reversibility of heat transformations, decrease of available energy and the places of the condenser and evaporator in the heat balance of a plant. In the treatment of steam-turbine action, a chapter discusses the flow of fluids through nozzles, while two succeeding chapters are concerned with heat reactions in the turbine and the steam injector also the kinetic theory of heat.

Any treatment of thermodynamics involves the use of algebra and calculus in derivation of equations, but the author has kept these as simple as possible and has made clear their application to the working of actual machines. Numerous problems emphasize this application and the place that thermodynamics occupies in the heat analysis of power machinery and plants and in their design.

ELECTRON TUBES IN INDUSTRY. By Keith Henney. Second edition; 539 pages, 6 by 9 in., 397 illustrations; cloth. McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, N. Y. 1937. Price $5.00.

The use of electron tubes in industry has passed the stage where anybody can afford to ignore them. They have invaded every field and are used for all sorts of purposes. Time was when an electron tube in an industrial application was somewhat of a curiosity—the antithesis of the bull in the china shop. It was something that was installed but not anything with which the engineer or plant superintendent seriously concerned himself.

Today a different situation prevails. The electron tube has become a common and extremely useful tool and in its metal form, at least, it is as rugged as almost any ordinary electrical device. "Time alone," says the author of this book, "will tell how important it will become in industry."

The purpose of the book is to acquaint industrial and power plant engineers, teachers and students with the many applications of electron tubes. It is specific; it tells what is being done with tubes in industry now and how it is being done. In many instances it indicates the possibilities of the extended use of these tubes. In all possible cases the economics of each application is discussed.

Although it is only two years since the first edition of this book appeared, there has been a great increase in the variety of applications of tubes in that time and Mr. Henney has incorporated all the more important of these new uses in this new edition. The variety of applications and the ingenuity of many of them is quite astonishing. As editor of "Electronics" Mr. Henney is well qualified to present a thoroughly practical book on this subject.

WATER TREATMENT AND PURIFICATION, by William J. Ryan. 6 by 8 in., 242 pages, 60 illustrations. Cloth, $2.50. McGraw-Hill Book Co., New York, N. Y.

Based on 10 years of experience and material from technical journals and papers in the transactions of engineering societies, this book is a summary of methods of water analysis, softening, filtering and purification, dealing especially with requirements for boiler feedwater. For those wishing to make a more intensive study, a bibliography on each topic is given at the end of the chapter devoted to that topic.

Division is into 12 chapters covering, Impurities, Sedimentation and Coagulation, Filtration, Analysis, Lime and Soda Ash, Zeolite, Boiler Feed, Disinfection, Tastes and Odors, Miscellaneous Treatments, Corrosion. Naturally, the discussion in each division is condensed, but in each case the principal points are covered and reactions and methods are given in sufficient detail for most practical purposes. Limitations of each method and precautions to be taken when using it are clearly stated.

In the two chapters on Boiler Feed, the causes of scale, priming, embrittlement and corrosion are given, followed by a summarization of what various methods of treatment will accomplish in overcoming these difficulties, and the adaptability of the different methods to size and arrangement of boiler plants. Closely allied is the discussion of corrosion in tanks and pipe lines and how to prevent it, by removing oxygen, expelling carbon dioxide and adding an alkali.

The book well serves its purpose of giving a summary and birds-eye view of its subject with complete references for those who seek more detailed information.

STEAM POWER STATIONS. By Gustaf A. Gaffert; first edition; 560 pages, size 6 by 9 in., fully illustrated, cloth. McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, N. Y., 1937. Price $4.50.

There has been a need for a good book on steam power stations, a work which would not only present the principles underlying the operation of modern power plant equipment but which would at the same time integrate all the various elements into a complete unit. The power plant today is no longer, or rather *should be* no longer a more or less haphazard collection of separate devices, but a complex unit involving many elements or components all of which are highly coordinated. Today a boiler can no longer be considered apart from the furnace, the combustion apparatus or the draft equipment. We speak of steam generators today and by this we imply the entire unit, combustion apparatus, furnace, air heaters, boiler, superheater, etc. In the same way the power station as a whole must be considered a unit. In this book it has been Mr. Gaffert's aim to fill this need. His many years of practical experience in actual power plant design impressed upon him the need for a work which would satisfy this need and at the same time provide him with the groundwork on which to plan such a book. Later, his experience as Assistant Professor of Heat Power Engineering at Worcester Polytechnic Institute gave him further insight into the mental equipment and requirements of the engineering student in this respect. His knowledge of steam power plant design is first hand.

In this book he begins with a treatment of fundamentals and develops them in such a way as to allow the practical man as well as the student to expand his knowledge progressively through the more difficult subjects to the goal—the complete integration of all machinery. The treatment throughout is simple and is, essentially, non-mathematical. No mathematical knowledge beyond the solution of simple equations is necessary.

Chapters I through to XVIII deal with equipment and steam machinery characteristics. Chapters XIX through to XXIV are concerned with economics and the integration of the machinery. The author has confined himself to only the mechanical engineering features of the steam power plant, leaving to other standard works the structural and electrical considerations. An interesting chapter at the end of the book on binary vapor cycles provides a general appreciation of a field which may well become a vital element in power plant design in the future.

LECTURES ON ABRASIVES AND GRINDING. Prepared by Norton Co., Worcester, Mass. Size 8½x11, paper bound, planographed, 79 pages.

This course of 10 lectures has been prepared primarily for use in educational institutions. These lectures cover general information on the history and development of grinding, natural abrasives, manufacture of artificial abrasives, grinding wheels, characteristics and fundamental principles of grinding practice. The arrangement of the text is logical, orderly and well illustrated, and, because of the wide use of abrasives in modern industry, should be of wide-spread interest, particularly to industrial engineers and educators.

THE ELECTRICAL YEAR BOOK, 1937, size 4 by 6 in., 380 pages, illustrated, cloth. Published by Emmott & Co., Ltd., Manchester, England. Price 1/6 net. This edition of this well-known little handbook, contains the same useful material which have made it so popular among those who have to do with or use electrical machinery and in addition has some new features. Lighting for example has been given especial attention and the section on lighting circuits and switching has been thoroughly revised and brought up to date. It is a handy little volume well worth the low price it sells for; less than 40 cents, American money.

INDEX TO A.S.T.M. STANDARDS and Tentative Standards is a 120-pg. publication giving information on all of the 796 standards as of January 1, 1937. All items are listed under appropriate key-words according to the particular subjects they cover. As a convenience a list is given of the specifications and tests in numeric sequence of their serial designations. Copies of this publication are furnished without charge on written request to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, Pa.

"Interpreting Company Financial Statements for Employees," is the title of a report issued by the Metropolitan Life Insurance Co., based upon a survey made by the Policyholders Service Bureau, One Madison Ave., New York City. Various methods used by a number of companies in making financial statements clear to the average employee are described. Among them are simplification of the language used in customary stockholder report, the question and answer method illustrations of the statement through the mediums of tables and charts, and statements broken down on a "per employee" basis. Illustrations of these and other methods have been selected from those in use and are reproduced in the report. Companies whose practices are described include General Electric Co., Baltimore Transit Co., Ludlum Steel Co., Barcalo Manufacturing Co., Cluett Peabody Co., Westinghouse Electric & Manufacturing Co., Elgin Watch Co., Standard Oil Co. (N. J.), Eastman Kodak Co., and General Motors Corp. Copies are available to those interested.

Twelve Extensive technical papers and large amount of discussion comprising the Symposium on Radiography and X-ray Diffraction Methods were prepared by outstanding authorities in the field. Six of the papers deal with radiography, covering principles, foundry applications, radiography in the welding shop, miscellaneous applications of radiography and fluoroscopy, radiographic specifications, and gamma-ray radiography and its relation to X-ray radiography. An appendix to this latter paper provides instructions for radiography with radium. The six papers devoted to diffraction cover equipment and methods, constitution of alloys, chemical analysis, determination of particle size, applications to nonmetallic materials, and to problems of cold work, preferred orientations, and recrystallization. The 350 pa. publication is profusely illustrated with 145 halftones and 50 line cuts. Copies in cloth binding can be obtained from American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa., at $4 each. Special prices are in effect on quantity orders and for educational work.

The seventh edition of its Standards for the pump industry has just been published by Hydraulic Institute. The enlarged publication has been completely rewritten and rearranged and much new material has been added, such as a new pump test code, charts for figuring friction of petroleum products in pipe lines, specific pump speed curves, pressure-temperature curves for pumping hot water and chart showing resistance of valves and fittings to flow of fluids. Recommendations of materials to be used in pumps handling various liquids, instructions for installing and operating different types of pumps, and much other material has been revised and brought up to date.

Price of the book is $1.00 and copies may be had by addressing the Secretary, C. H. Rohrbach, 90 West Street, New York.

United States Rubber Products, Inc., 1790 Broadway, New York city, has released "An Album of Familiar Belts," a folder containing 25 reproductions of photographs taken in the field and in the factory. These pictures show interesting and unusual installations of transmission belts in a variety of industries, as well as a number of exceptional studies made by Margaret Bourke-White, chief photographer for Life, at U. S. Rubber's Passaic laboratory and factory.

Bulletin 370, recently published by the Johnson Bronze Co., New Castle, Pa., lists over one hundred additional general purpose bearing sizes making the total number of sizes now available from stock over 700. Illustrated, thorough and complete in detail, the new bulletin contains information on a most complete line of machine finished bearings and a bronze bearing service.

The Electric Controller & Mfg. Co., Cleveland, Ohio, has issued a new descriptive booklet, No. 67, which is devoted to their line of steel clad motor control apparatus.

"Automatic Switchgear" is the title of a 6-page leaflet, GEA 2472, recently issued by the General Electric Co.

"The Double-Duty Smoke Sentry" is the title of a 4-page leaflet issued by Boiler Room Equipment, Inc., 45 W. 45th St., New York. This describes a new smoke and combustion indicator which utilizes a photoelectric cell. It causes the intermittent ringing of a bell or the flashing of a lamp whenever the firing is so bad as to cause inefficient combustion or smoke. It warns the attendant he is approaching the correct firing point by slowing down the interval between signals.

Heavy duty, disc-type, water meters in 3 and 4 in. sizes, are described in a new bulletin, M-975-B34, issued by the Worthington-Gamon Meter Co., Harrison, N. J. These units are recommended for hotels, apartment buildings, mercantile establishments, large office buildings, manufacturing plants and other locations where the demand is too high for the usual type of disc meter.

Johnson Electric Motor Service Bulletin, EM-7, is the title of a new catalog recently published by the Johnson Bronze Co., New Castle, Pa. It is a guide to the bearing user and is complete in every detail. Over 200 electric motor bearings are shown.

Goulds Pumps, Inc., are distributing a new bulletin, No. 208, describing Close-Cupld Centrifugal Pumps. Twenty-one sizes of these pumps give a wide range of capacities and heads: 5 to 1600 g.p.m., up to 525 ft.

Under the title "Empire — The World's Finest First Quality Fire Brick," the A. P. Green Fire Brick Co. of Mexico, Mo., has recently issued a booklet describing the methods of manufacture used by this company in the making of its high quality refractory. The booklet tells an interesting story and includes many illustrations which make it attractive reading.

In a new bulletin, No. 3600-A1, Fairbanks, Morse & Co. describes the construction and applications of its Model 36 Diesel power units, offered in various combinations, with rating as low as 10 hp., the smallest in the company line.

H. W. Porter & Co., 825 Frelinghuysen Avenue, Newark, N. J., is distributing a novel booklet which clearly shows, step-by-step, how to install Therm-O-Tile. To read the booklet properly one must start with the last page instead of the customary first page, and follow through five important steps to the completed installation.

Among the new publications recently issued by Westinghouse Electric and Mfg. Co. are leaflet 20568-A describing midget contactors and line starters, and "Descriptive data 75-240" on the subject of Luminous Tube Transformers.

"Solenoid Valves for Automatic and Remote Control" is the title of Catalog No. 20 recently issued by the Automatic Switch Co., 154 Grand St., New York, N. Y. This describes automatic valves for use in connection with air, gas, steam or liquids. It is an attractive 32-page catalog, well illustrated and containing full engineering data and prices.

Under the title "The Art of Proportioning," D. W. Haering & Co., Inc., 3408 W. Monroe St., Chicago, Ill., has issued a new 24-page illustrated catalog describing the operation and application of proportioning equipment. This booklet explains the use of the Haering fluid piston principle including detailed descriptions of the new Model "B" Junior and Model "B" Twin feeders. The construction, operation and application of a variety of proportioning feeders are described along with photographs of installation. The use of pitot tubes, fluid pistons and proportioning of various chemicals is discussed in detail.

Laboratory Thermometer and Hydrometer catalog, No. 1100A, has recently been published by the C. J. Tagliabue Mfg. Co. of Park & Nostrand Aves., Brooklyn, N. Y. In addition to the regular line of extreme precision and standard grade TAG thermometers and hydrometers, this catalog now includes complete listings of the widely used A.S.T.M. thermometers with illustrations.

Friez air meters, draft and air filter gages are described and illustrated in Bulletin F sent out by Julien P. Friez & Sons, Inc., Baltimore, Md.

Allis-Chalmers Mfg. Co., Milwaukee, Wis., has issued a new engineering bulletin 1186, containing information on their Type "SB" Outage-Free Distribution Transformer. This publication discusses the principles of operation of the units, how transient surges are diverted and the methods used to provide protection, as well as construction details of the transformers, and protective equipment.

A 16-page publication describing polyphase detachable meters has been announced by the Westinghouse Electric and Mfg. Co. These meters are suitable for any application where a two element watthour meter is required. The publication describes the application, construction, features, dimensions, wiring diagrams and performance characteristics of CS-2 polyphase detachable meters for use with transformers, CS-5 two element detachable self-contained meters, CS-7 detachable power and lighting self-contained meters, and CS-8 detachable polyphase self-contained meters with 3 current and 2 potential coils. Sockets for these meters are also described in the publication.

Davis Regulator Co., 2508 S. Washtenaw Ave., Chicago, is distributing a chart designed to enable anyone to make a quick and accurate selection of the proper type of pressure reducing valve to use for any given kind of service on steam, gas, air, oil, or water.

A 16-page publication designated Descriptive data 36-220 describing Westinghouse outdoor bus supports has recently been released. Specifications for apparatus insulators for standard and heavy duty service, bus supports for various types of mountings, and clamps for outdoor channel busses are fully described in the booklet.

For the convenience of those dealing with petroleum and petroleum products, the C. J. Tagliabue Mfg. Company issue a number of charts prepared either by their

own organization or reprinted by permission of the original copyright owners.

The first is for making viscosity-temperature comparisons (including Saybolt Universal and Furol, Redwood, Engler and kinematic) or for determining viscosity index numbers from known viscosities. This chart, No. 55469, measures 22 by 16 in. Put up in pads of thin paper, 25 charts each, it is known as No. 55469 and sells for $2.50 per pad. As No. 55476 it is printed on heavy bristol board and sells at $1.25 each.

Viscosity-Temperature Chart, A.S.T.M. Serial No. 341-32T, is also printed, in two forms. No. 55466 is 21½ by 16¼ in. and ranges from —30 to +450 deg. F. with viscosities from 37 to 100,000,000 Saybolt Universal seconds, with the kinematic viscosity scale printed on the chart for conversion purposes. Put up in pads of 25 charts each, it sells for $1.50 a pad. The chart, 8½ x 11 in size, abridged to cover temperature range of —10 deg. to 300 deg. F. and viscosities of 37 to 100,000 seconds, is known as No. 55468. It is put up in pads of 50 charts each and sells for $2.00 a pad.

Viscosity blending chart providing a convenient method for obtaining the viscosity of blends measures 13 by 11 in. and is known as No. 55467. This chart is put up in pads of 25 charts each at $1.00 a pad.

THE LINCOLN ELECTRIC Co., Cleveland, Ohio, has recently issued its Welder Specification Bulletin No. 318, dealing with the Lincoln Shield-Arc SAE Welder, which not only describes this unit but includes data on the dual continuous control which gives any type of arc for each and every flow of welding current.

MOTOR-MOUNTED pumps are described in a catalog issued by the De Laval Steam Turbine Co., Trenton, N. J. This unit consists of a centrifugal pump mounted upon the frame of an electric motor to form a compact unit with only one shaft and two bearings, requiring no special foundation or sub-base. It can be mounted in any position, upside down or with the shaft vertical, or may be placed upon a hand truck or slung for portable use. Dimensions and other details are given for pumps of capacities from 5 to 1200 g.p.m. and for heads from 10 to 230 ft., also pipe friction tables and instructions for selecting and installing pump units.

PYROMASTER, the new recording round-chart potentiometer recently announced by The Bristol Co., Waterbury, Conn., is described in bulletin No. 482. In this bulletin will be found drilling dimensions, chart lists, and other engineering data pertaining to the Pyromaster in the following forms: pyrometer, tachometer, resistance thermometer, millivoltmeter, and milliammeter.

Copies of bulletin No. 482 will be sent to any one interested in the subject of measurement by means of the potentiometer system.

A REFERENCE TABLE for calculating necessary capacitor kv-a. to correct load to desired power-factor has been compiled by the Cornell-Dubilier Corporation. This chart, among other functions, computes power-factor to any desired percentage. The reverse side of the table shows the amount of current drawn by capacitors and also specifies the sizes of switches to be used with varying sizes of capacitors.

The fact that the chart is more comprehensive, accurate and simple to use than a graph, makes it a most valuable desk reference for the engineer, factory superintendent and maintenance manager. Address requests to the Cornell-Dubilier Corporation, South Plainfield, New Jersey.

HEAT CORROSION and abrasion resisting material for the power plant is described in a 4-page Bulletin 3720 issued by the Duraloy Co., Pittsburgh, Pa. Soot blower tubes, baffles, dampers, superheater hangers and supports and miscellaneous parts made from chrome-iron and chrome-nickel alloys are described and applications illustrated.

DESCRIBING its complete line of temperature equipment, recording pressure gages, air operated and self-operated temperature and pressure controls and steam traps, a new 35-page catalog, No. 101C, has just been issued by H. O. Trerice Co., 1420 Lafayette Blvd. West, Detroit, Mich.

APPLICATION of Kisco ventilation and exhaust equipment is described in a 32-page bulletin issued by the Kisco Co., Inc., 4414 W. Papin St., St. Louis, Mo.

LEEDS & NORTHRUP Co., 4901 Stenton Ave., Philadelphia, have just issued an unusual bulletin on the Silver Anniversary model Micromax recorder. The bulletin is cut to actual shape, about one-half model size, of the recorder and pages open up and swing out as would the case and mechanism of a real instrument, to show the actual construction and arrangement of the parts.

STRENGTH PLUS as supplied by Monel for mechanical jobs, covering power equipment, piping, transmission lines, railway equipment, automobile and marine plants is discussed and applications illustrated and described in an attractive 48-page publication issued by The International Nickel Co., Inc., 67 Wall St., New York, N. Y.

The World's Highest Chimney

IN A NATION which boasts of the world's hightest building, the world's largest power plants, the largest dams, the highest voltage and many other "superlatives" one might expect also to find the tallest chimney. But, curiously enough, the world's highest chimney is not in America but in Korea. And this chimney is not part of a power plant but a smelter.

This chimney, shown in the accompanying photograph was built for the Nippon Mining Co., at Chinnampu, Korea. The contractor was the Oriental Compressol Company of Tokyo, Japan, the chimney being built under the Weber system of reinforced concrete chimney construction, and with the Weber unit forms.

It is 618 feet from the bottom of the foundation to the top of the chimney. The inside diameter at the top is 25 feet. The thickness of the shaft at the foundation is 37 in., and at the top of the chimney is 7 in. It has a lining which is 6 in. thick, reinforced both vertically and horizontally, and is 180 ft. high. There is an air space of 4 in. between the lining and the outer shell, or shaft. The foundation is circular, with a diameter of 97 ft. and contains 3200 cu. yds. of concrete. There are 4400 cu. yds. of concrete in the shaft. The shaft contains 320 tons of steel bars, with 120 tons of steel bars in the foundation. The reinforcement in the shaft consists of vertical bars and horizontal rings. The foundation is 18 ft. thick.

This chimney is serving a gold smelter. A smelter is about the only kind of an institution that would require a chimney of anything like this height, and only for the purpose of avoiding the destruction of vegetation by the smelter gases. There are some industrial plants, such as cement plants and some steel operations, where chimneys are built as high as 300 ft. but this is an unusual height as it is not usually necessary to build chimneys so high.

The foundation of this chimney was built in the Fall of 1935. As there is very cold weather in Korea they did not proceed with the shaft until the Spring of 1936. About the middle of March they started the shaft of the chimney, and on September 18th it was completed to its height of 600 ft. above the top of the foundation. A feature of interest is the fact that there were no accidents connected with the construction of this shaft.

Power Plant Construction News

Calif., Los Angeles — Metropolitan Water District of Southern California, 306 West Third Street, will receive bids until April 15 for 15,000-volt indoor type disconnecting switches, switch and bus compartments for each of five pumping stations on Colorado River Aqueduct, known as Intake, Iron Mountain, Gene, Eagle Mountain and Hayfield Stations, respectively, as per Specifications No. 194.

Calif., Newark—Westvaco Chlorine Products Corporation, 405 Lexington Avenue, New York, N. Y., plans installation of electric power equipment in new plant at Newark, where company has recently acquired California Chemical Co. It will comprise a group of seven one and multi-story buildings. Entire project will cost close to $1,000,000. E. P. Wilson is chief engineer for company. Award for buildings has been made to H. K. Ferguson Co., Hanna Building, Cleveland, Ohio.

Calif., Oakland—Pacific Gas & Electric Co., 245 Market Street, San Francisco. Calif., has plans for new addition to steam-electric generating plant at Oakland, with installation of equipment to increase capacity from 83,000 to 155,000 hp. Award for two main generator units has been made to General Electric Co., Schenectady. N. Y., and contracts for other equipment will be placed soon. Entire project will cost about $5,000,000.

Calif., Sacramento — Bercut-Richards Packing Co., North B and Seventh Streets, plans installation of electric power equipment in two new additions to food products packing and canning plant, 240x320 ft., and 240x280 ft., respectively. Entire project will cost close to $175,000.

Ind., Evansville — Mead-Johnson, Co., St. Joseph Avenue and Ohio Street, plans installation of electric power equipment in new four-story and basement addition to prepared food products plant. Entire project will cost close to $150,000. Superstructure will begin soon.

Ind., Valparaiso — Board of Public Works plans new diesel engine-operated pumping station in connection with extensions and improvements in municipal waterworks. A 500,000-gal. capacity elevated steel tank and tower will be installed. Entire project will cost about $200,000, in which amount bond issue has been authorized. Charles Brossman, Chamber of Commerce Building, Indianapolis, Ind., is consulting engineer.

Iowa, Waterloo—Rath Packing Co., Sycamore and Elm Streets, meat packer, plans installation of electric power equipment in new five-story and basement addition to plant, for which superstructure will begin in April. Entire project will cost close to $250,000. H. Peter Henschien, 59 East Van Buren Street, Chicago, Ill., is architect and engineer.

Kan., Paola—Common Council has plans maturing for new municipal electric light and power plant, with installation of 1000 kw. generating unit and auxiliary equipment. An electrical distributing system will be constructed for service in different parts of municipality. Special election has been called April 6 to approve bonds for $225,000 for entire project. W. B. Rollins & Co., Railway Exchange Building, Kansas City, Mo., are consulting engineers.

Kan., St. Francis—Common Council plans extensions and improvements in municipal electric power plant, including installation of new diesel engine-generator unit and auxiliary equipment. Cost about $85,000. E. T. Archer & Co., New England Building, Kansas City, Mo., are consulting engineers.

La., Lake Charles—Swift & Co., Union Stock Yards, Chicago, Ill., meat packers, plan installation of power equipment in new plant on Old Spanish Trail, near St. Charles city limits. Entire project is reported to cost over $100,000.

La., Monroe—City Council is considering extensions and improvements in municipal electric power plant, including installation of new generating unit, two boilers and complete accessories. It is proposed to arrange a bond issue of $1,500,000 for this and other municipal improvements, including extensions in electric lines, expansion and improvements in sewerage system, new warehouse for municipal power station and other work.

La., Thibodaux—La Fourche Sugars Corporation, O. J. Mire, president, recently organized, plans installation of electric power equipment in connection with expansion and improvements in former Leighton Sugar Mill, about 2 miles from Thibodaux, which has been acquired for plant. Entire project will cost over $100,000.

Md., Baltimore — Rustless Iron & Steel Corporation, 1001 Edison Highway, plans installation of electric power equipment in new additions to mill; a new power substation will be built, equipped for large capacity. Entire project will cost over $600,000.

Mass., Marblehead—Board of Selectmen has plans under way for extensions and improvements in municipal electric light and power plant, including installation of additional equipment for increased capacity. It is expected to ask bids at early date. No estimate of cost announced.

Mich., Detroit—Coca-Cola Bottling Co., 3609 Gratiot Avenue, plans installation of electric power equipment in new two-story bottling plant. Entire project will cost close to $100,000. It is proposed to begin work soon.

Mich., Detroit—Packard Motor Car Co., 1580 East Grand Boulevard, plans installation of electric power equipment in two new additions to plant. Entire project will cost over $350,000. Albert Kahn, Inc., New Center Building, is architect and engineer.

Minn., Halsted — Common Council has plans under way for a municipal light and power plant. Estimated cost about $40,000. Bids are scheduled to be asked soon. Ealy G. Briggs, 1957 University Avenue, St. Paul, Minn., is consulting engineer.

Nev., Reno — Construction Service, Veterans' Administration, Washington, D. C., will receive bids until May 4 for complete boiler plant and equipment in connection with new hospital, Building No. 1, at Reno, for which bids on general contract will be received at same time.

N. C., Winston-Salem—Hanes Hosiery Mills Co., plans installation of electric power equipment in new addition to knitting mill. Entire project will cost about $80,000. James G. Hanes is president.

Ohio, Cleveland—White Motor Co., 842 East Seventy-ninth Street, plans installation of electric power equipment in new additions to motor truck manufacturing plant, including improvements in present works. Entire project will cost close to $2,000,000. Robert F. Black is president.

Ohio, Painesville—City Council, C. S. Fullerton, city manager, is arranging for early preparation of plans for extensions and improvements in munipical electric power plant, including installation of turbine unit, boilers and auxiliary equipment. Cost estimated close to $80,000. F. O. Wallene, 17114 Ernadale Avenue, Cleveland, Ohio, is consulting engineer.

Ohio, Toledo—DeVilbiss Co., 300 Phillips Avenue, manufacturer of spraying apparatus and devices, plans installation of electric power equipment in new addition to plant on Concord Street. Entire project will cost close to $100,000. Austin Co., 16112 Euclid Avenue, Cleveland, Ohio, is engineer.

Ohio, Toledo—Gulf Refining Co., Gulf Building, Pittsburgh, Pa., plans installation of power equipment in new additions to oil refining plant at Toledo, to occupy large adjoining tract of land, recently acquired. Power house will be enlarged and additional equipment installed. Entire project will cost over $2,000,000.

Ohio, Toledo—Pure Oil Co., 35 East Wacker Drive, Chicago, Ill., plans installation of power equipment in connection with expansion and improvements in oil refining plant at Toledo. Capacity will be more than doubled. Entire project will cost close to $2,000,000.

Pa., Bradford—Bradford Oil Refining Co., Bradford, plans installation of power equipment in connection with expansion and improvements in oil refinery at Foster Brook, Pa., including gasoline refining division. An addition will be built to power house at plant, with installation of new equipment. Entire project will cost about $300,000. H. C. Salisbury is plant superintendent.

Pa., Mercersburg—Mercersburg Ice & Cold Storage Co. has plans under way for new cold storage and refrigerating plant on Park Street. Cost close to $60,000, with equipment.

Tenn., Memphis — Continental Gin Co., 212 Poplar Street, plans installation of electric power equipment in new two-story addition to cotton ginning machinery manufacturing plant, 90x150 ft. Entire project will cost over $75,000. E. L. Harrison, Fidelity Bank Building, is architect.

Wash., Everett—Soundview Pulp Co. plans installation of electric power equipment in new addition to bleached sulphite pulp mill, comprising third unit at plant. Entire project will cost about $1,000,000. Leo S. Burdon is general manager. Work is scheduled to begin at early date.

Wis., Neillsville — Neillsville Milk Pool Cooperative, Neillsville, F. A. Viergutz, manager, plans new boiler house, 30x50 ft., in connection with new two-story addition to milk and dairy products plant. Entire project will cost over $50,000. E. F. Klingler, Amery, Wis., is architect.